Best Available Copy

Report No. CG-D-22-80

ADA084214

STUDY TO MODIFY THE VULNERABILITY MODEL OF THE RISK MANAGEMENT SYSTEM

MAY 1 6 1980

A

FINAL REPORT

Document is available to the public through the National Technical Information Service, Springfield, Virginia 22151

FEBRUARY 1980

Prepared for

U.S. DEPARTMENT OF TRANSPORTATION
United States Coast Guard
Office of Research and Development
Washington, D.C. 20590

NOTICE

DISCLAIMER NOTICE

THIS DOCUMENT IS BEST QUALITY PRACTICABLE. THE COPY FURNISHED TO DTIC CONTAINED A SIGNIFICANT NUMBER OF PAGES WHICH DO NOT REPRODUCE LEGIBLY.

Technical Report Documentation Page

1. Report No. USCG-D-22-80	2. Government Accession No. AD-A084 214	3. Recipient's Catalog No.
4. Title and Subtitle Study To Modify the Vulnerability Model of the Risk Management System		5. Report Date February 1980
		6. Performing Organization Code
7. Author(s) Willard W. Perry William P. Articola		8. Performing Organization Report No. 212
9. Performing Organization Name and Address Enviro Control, Inc. One Central Plaza 11300 Rockville Pike Rockville, Maryland 20852		10. Work Unit No. (TRAIS)
		11. Contract or Grant No. DOT-CG-74188-A
12. Sponsoring Agency Name and Address U.S. DEPARTMENT OF TRANSPORTATION U.S. COAST GUARD Office of Research and Development Washington, D.C. 20590		13. Type of Report and Period Covered Final Report
		14. Sponsoring Agency Code DOT/USCG (G-DMT)

15. Supplementary Notes

The U. S. Coast Guard Office of Research and Development's technical representative for the work performed herein was Dr. M. C. PARNAROUSKIS

16. Abstract

The Vulnerability Model (VM) is a computer model which simulates hazardous materials spills and computes the consequences to people and property from resulting fires, explosions, or toxic vapors. This report describes recent work performed to prepare the VM for operational use. Four specific tasks or developments are described:

(1) Development of the User Interface Module (UIM), an easy-to-use conversational program which enables inexperienced or occasional users to set up and run VM simulations easily and reliably with little or no training,

(2) Development of a series of VM output display routines which display the results of VM simulations on CRT terminals or hard copy plotters,

(3) Development of ready-to-use Geographical/Demographic files for Los Angeles and New York Harbors (a file for New Orleans already exists),

(4) Performance of a number of VM spill simulations for selected chemicals in Los Angeles and New York Harbors to operationally test the UIM/VM system and to provide a hazard ranking of the selected chemicals.

17. Key Words Vulnerability Model; Population Vulnerability Model; Hazardous Materials Spills; Spill Simulations; Risk Management	18. Distribution Statement Document is available to the public through the National Technical Information Service, Springfield, Virginia 22151

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	210	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

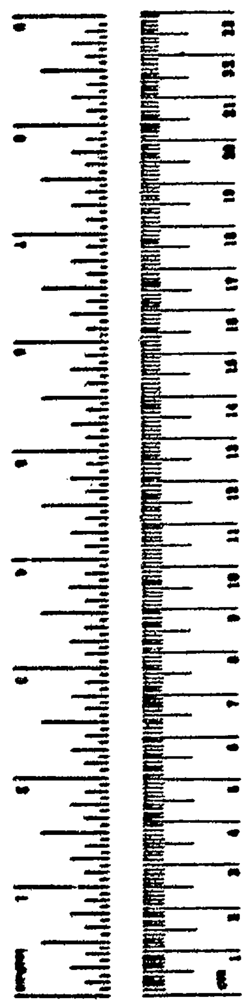
408 195

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

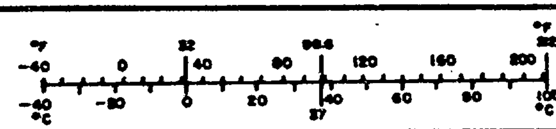
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



PREFACE

The Vulnerability Model (VM), a computer model developed by Enviro Control, Inc. for the U.S. Coast Guard, simulates the development of hazardous materials spills and computes the consequences to people and property from resulting fires, explosions, or toxic vapors. It is being developed as a major component of the U.S. Coast Guard Risk Management System for evaluating the cost-benefits of alternate means for reducing the risks and consequences of marine accidents involving hazardous materials. Recently the U.S. Coast Guard has adopted Population Vulnerability Model (PVM) as the official name for the model. This change has not been incorporated in this report and VM is used throughout, a name which is synonymous with PVM.

The VM has undergone a phased development. This report describes the work under the latest phase, which is to prepare the VM for operational use. The work was performed under the overall technical direction of Dr. Michael C. Parnarouskis, the U.S. Coast Guard Project Officer, who must be given credit for the basic operational concepts developed and incorporated in the VM and reported here. Particular mention is made of his role in the design of the User Interface Module (UIM), a valuable addition to the VM which transforms the highly complex VM simulation into an easy-to-use analytical tool.

Acknowledgement is made also of the contribution of Dr. Alan L. Schneider who assisted in selection of the chemicals for simulation and provided data on the characteristics and transportation of hazardous chemicals.

Finally, the efforts of John Remmert and Dr. Chi K. Tsao are gratefully acknowledged. Mr. Remmert programmed the initial version of the Users Interface Module, and Dr. Tsao did much of the work on the displays and contributed substantially to their documentation in Chapter III.

A 23

CONTENTS

Chapter 1

INTRODUCTION AND SUMMARY

A. *INTRODUCTION*

This report describes the work performed during the past year to prepare the U.S. Coast Guard Vulnerability Model (VM) for operational use. Four specific tasks were carried out:

- Development of the User Interface Module (UIM), an easy-to-use conversational program which enables inexperienced or occasional users to set up and run VM simulations easily and reliably with little or no training.
- Development of a series of VM output display routines which display the results of VM simulations on CRT terminals or hard copy plotters.
- Development of ready-to-use Geographical/Demographic files for Los Angeles and New York Harbors (a file for New Orleans already exists).
- Performance of a number of VM spill simulations for selected chemicals in Los Angeles and New York Harbors to operationally test the UIM/VM system and to provide a hazard ranking of the selected chemicals.

The accomplishments of the four tasks are summarized in the Summary section of this chapter and are described in detail in the following chapters (Chapters 2 through 5). Appendix A gives a brief description of the Vulnerability Model (VM) for readers unfamiliar with its characteristics and its use. More complete information on the VM is provided in references [1] through [5].

---

[1] Eisenberg, N. A., C. J. Lynch, and R. J. Breeding, *Vulnerability Model: A Simulation System for Assessing Damage Resulting from Marine Spills*, Final Report, CG-D-136-75, NTIS AD-A015 245, prepared by Enviro Control, Inc., for Department of Transportation, U.S. Coast Guard, June 1975.

[2] Rausch, A. H., N. A. Eisenberg, and C. J. Lynch, *Continuing Development of the Vulnerability Model...*, Final Report, prepared by Enviro Control, Inc., for Department of Transportation, U.S. Coast Guard, February 1977.

[3] Rausch, A. H., C. K. Tsao, and R. M. Rowley, *Third-Stage Development of the Vulnerability Model...*, Final Report, prepared by Enviro Control, Inc., for Department of Transportation, U.S. Coast Guard, June 1977.

[4] Rowley, R. M., and A. H. Rausch, *Vulnerability Model User's Guide*, Enviro Control, Inc., October 1977.

[5] Tsao, C. K., and W. W. Perry, *Modifications to the Vulnerability Model...*, Final Report, prepared by Enviro Control, Inc., for Department of Transportation, U.S. Coast Guard, March 1979.

B. SUMMARY

This section presents a brief summary of each of the four study tasks. Following the task summaries is a summary of additional VM program modifications that were made to improve the utility of the VM output tables and to correct VM logic errors that were found during the course of the work.

1. User Interface Module (UIM)

The UIM has been designed and developed to meet general specifications defined by the U.S. Coast Guard. It is a conversational program which interacts with the user to help prepare the inputs and the files needed to run the VM. Although it is a separate program from the VM, it is linked to the VM and all instructions and commands needed to run the VM are provided through the UIM. Instructions and explanatory material are built into the UIM so that the program is essentially self-explanatory and, in general, a user's manual is not needed to use the UIM. An abbreviated version of the file preparation conversation is provided in addition to the detailed instructional version, to enable the more experienced users to run VM simulations in as short a time as possible. Figure 1-1 is a flow diagram of the UIM illustrating its principal features and the key user options.

A key feature of the UIM is its ability to augment the data provided by the user, with information from its internal files, to provide a complete, consistent, and correctly formatted set of inputs for the VM. This internal data is data that is dependent on basic scenario inputs but is particularly difficult for the user to acquire; e.g., flame speeds, probit coefficients. These data have been prepared in advance and placed in the internal UIM Chemical Properties file. The UIM can perform VM simulations only for those chemicals which have been inserted in the UIM and checked out in advance. Currently, there are 27 hazardous chemical property sets incorporated in the UIM (see Table 2-2 in Chapter 2).

To validate its operational effectiveness, the UIM/VM system has been successfully exercised by engineering-oriented personnel with no VM or computer experience. A User's Operational Manual has been published which gives complete instructions on how to access and operate the UIM [6]. Included in the manual is a section which explains and interprets the VM output tables.

The UIM program documentation is provided in Chapter 2 below. This includes the program information needed for maintaining and updating the UIM as required to incorporate additional chemicals or user aids.

---

[6] Enviro Control, Inc., *User Interface Module (UIM) for U.S. Coast Guard Vulnerability Model (VM): Draft User's Operational Manual*, prepared for Department of Transportation, U.S. Coast Guard, June 1979.

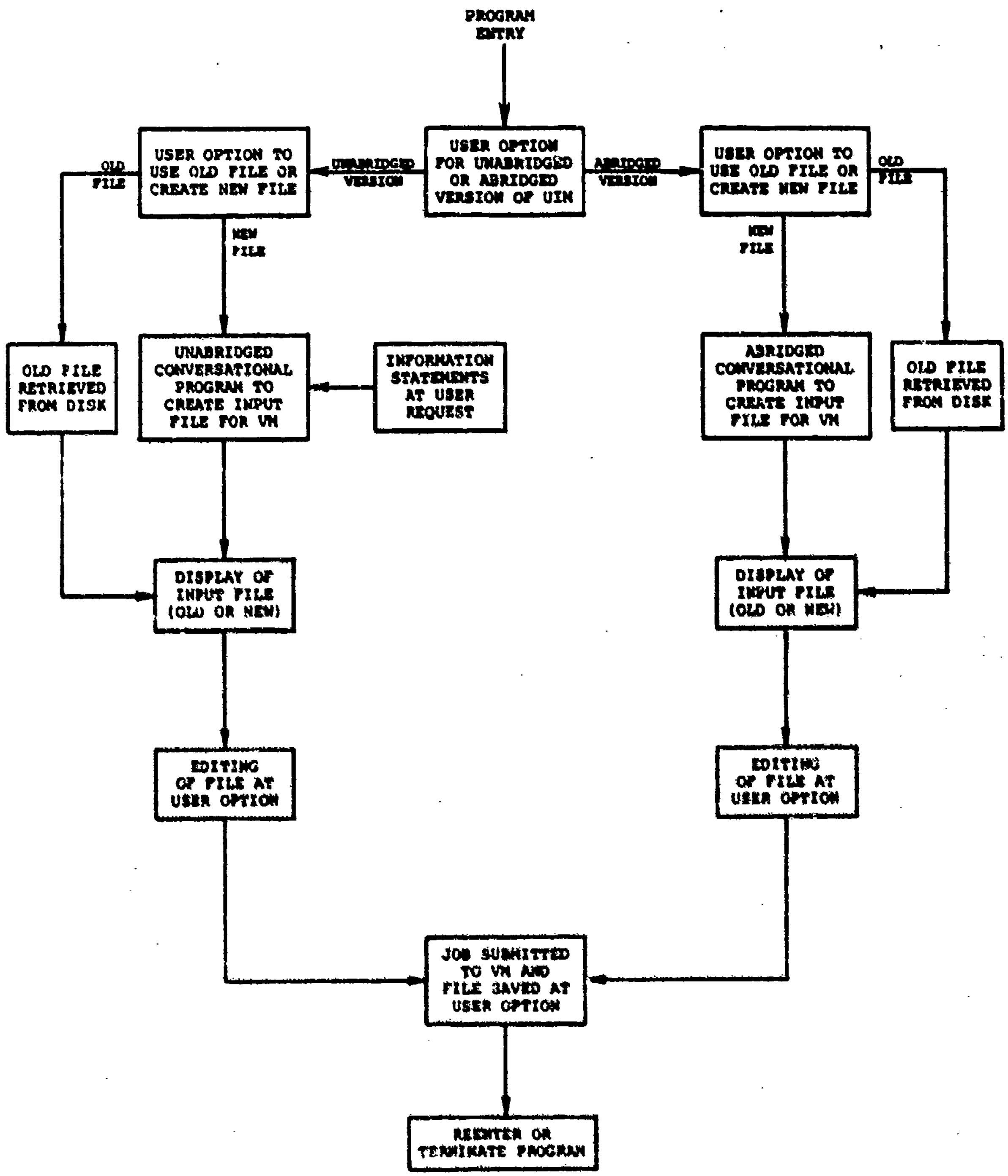


FIGURE 1-1. Structure of the UIM

2. *Graphical Displays*

Graphical routines have been developed to display the major results of the VM simulation on CRT terminals or hard copy plotters. Thirteen specific output displays have been developed, namely:

- Four isoconcentration displays
  - — irritation* threshold for puff and plume
  - — lower flammability limit for puff and plume
- Four injury** displays
  - — toxic injury for puff and plume (outdoors)
  - — flash fire and explosion injury
- Four lethality*** displays
  - — toxic lethality for puff and plume (outdoors)
  - — flash fire and explosion lethality
- One structural damage display

All displays are in the form of isoconcentration or isofractional damage contours overlaid on a schematic map of the geographical cells. Thus, the user obtains a visual accounting of which cells are affected, and to what degree.

An additional feature of the displays is the option of changing spill location, wind direction, or ignition center (where applicable) interactively without having to rerun the VM parametrically. This permits users to economically and rapidly estimate the effect on damage of changes in these parameters.

To incorporate the displays, the VM has been modified with the addition of six new subroutines. At the user's option, the display data are generated during the VM simulation and stored in a VM output file which can be called up and displayed anytime the user desires. Chapter 3 below describes the display routines and their derivations and gives instructions on how to use the displays.

---

*"Irritation" is a discomforting but nonincapacitating impairment.

**"Injury" is an impairment requiring hospitalization.

***"Lethality" implies immediate and lasting total incapacitation.

3. *Geographical/Demographic Files**

A methodology has been developed for generating Geographical/Demographic files to satisfy arbitrary specifications on the number of cells and the general location of the file. The key element of the methodology is a computer program which searches the census MEDList tape and identifies all census block groups that are located within a quadrilateral defined by a central point plus and minus a Δx and a Δy. The user initially inputs the quadrilateral which encompasses the appropriate area he is interested in. He then examines the results and repeats the process with a modified quadrilateral until he obtains the number of cells desired for the file. The maximum size of the Geographical/Demographic file that can be processed by the VM is 400 cells.

To reduce file generation cost and to overcome tape reading problems caused by differences in IBM and CDC software, intermediate MEDList tapes have been created which contain only those portions of the MEDList encompassing the harbor areas of interest. These intermediate files are then searched as described, to create the specific file limited to the particular area and number of cells desired.

Intermediate MEDList files were created for the New York City and Los Angeles areas. Three Geographical/Demographic files, each containing slightly less than 400 cells, were then created for the two cities: one for Los Angeles Harbor (San Pedro/Long Beach and the area immediately north of the harbor) and two for New York Harbor (the Perth Amboy vicinity and the Lower Brooklyn/Coney Island area). Together with the New Orleans Geographical/Demographic file, there are now four ready-made Geographical/Demographic files available for VM users.

Chapter 4 of this document describes in detail the generation and the characteristics of the Geographical/Demographic files.

---

*The Geographical/Demographic file consists of a file of census block groups or enumeration districts for a given geographical area. For each cell (census block group/enumeration district) in the file, the identifier, latitude and longitude of the cell center, the population, the number of structures within the cell, dollar value per structure, and ignition strength of the cell are specified.

4. *Spill Simulations*

To check out and test the UIM/VM system and the newly generated Geographical/Demographic files, a number of spill simulations were run for a variety of chemicals and spill scenarios at the New York and Los Angeles Harbors. The purpose of these simulations was twofold. In addition to validating the UIM/VM system, the simulations provide a means of evaluating or ranking the relative hazard potential of a series of hazardous cargoes selected by the U.S. Coast Guard.

The cargoes that were selected for simulation are listed in Table 1-1. These chemicals were chosen in part by an analysis of hazard properties (e.g., toxicity, flammability), and in part by consideration of shipment volumes. For the toxic chemicals, the probit coefficients were derived from an analysis of toxicity and health effects data in the literature, and for all the chemicals, the chemical/physical data needed for the UIM files was prepared and incorporated in the UIM.

Three spill sites were selected (two for New York and one for Los Angeles) and for each a standard environmental scenario was defined which was used for all chemicals. Table 1-2 defines the spill scenarios for each spill site. The only differences in spill simulations between chemicals (other than the chemical properties) was in the cargo characteristics. Tank capacities (and associated temperatures and pressures) were selected for each chemical which correspond to the maximum tank size that is customarily transported by water for that chemical. Table 1-1 gives the tank capacities assumed for each chemical cargo. For all cargoes, the identical rupture characteristics were simulated (hole size and location). Due to the different tank capacities the size of the spill varies with chemical, but the simulations are all consistent in that they represent the maximum amount that can be spilled from a specified type of rupture in a single tank.

The simulations were initially run by experts for the Perth Amboy scenario to check out the UIM/VM system operation. Based on an analysis of the results, errors and problems in the system were found and corrected. Then the simulations for the remaining scenarios were run by novices with a minimum of training and assistance. These latter exercises were completed successfully and demonstrated the operational acceptability of the UIM.

The results of the simulations were carefully analyzed for the purpose of ranking the relative hazards of the 15 chemicals. Table 1-3 summarizes the results of this ranking. The 15 chemicals fall into four hazard categories and seven hazard rankings.

TABLE 1-1

Simulation Scenario Cargo Characteristics

CHEMICAL NAME	CODE	TANK CAPACITY (m^3)	TANK HEIGHT (m)	CARGO PRESSURE[a] (atm)	CARGO TEMPERATURE[b] (°C)	HAZARD[c]
Acetaldehyde	AAD	3,000	15	1 (C)	Ambient	F
Acrylonitrile	ACN	3,000	15	1 (C)	Ambient	T
Ammonia (Anhydrous)	AMA	10,000	20	1 (V)	-33	T
Chlorine	CLX	182	7	1 (V)	-33	T
Dimethylamine	DMA	3,000[d]	15	2.5 (C)	Ambient	F
Ethyl other	EET	3,000[d]	15	1 (C)	Ambient	F
LNG	LNG	25,000	22	1 (V)	-161	F
LPG	LPG	10,000	20	1 (V)	-40	F
Methyl bromide	MTB	3,000	15	1 (C)	4	T
Methyl chloride	MTC	3,000[d]	17	1 (V)	-24	F
Octane	OAN	4,000	17	1 (C)	Ambient	F
Pentane	PTA	4,000	17	1 (C)	Ambient	F
Propylene oxide	POX	3,000	15	1 (C)	Ambient	T,F
Toluene	TOL	4,000	17	1 (C)	Ambient	T
Vinyl chloride	VCM	6,000	17	1 (V)	-14	F

For all chemicals: fraction filled = 0.98
hole diameter = 2 m
height of centerline above waterline = 1 m
height of hole bottom above tank bottom = 0

[a](C) = closed tank; (V) = vented tank

[b]Ambient = sea temperature

[c]F = flash fire; T = toxic

[d]Double tank capacity (6,000 m^3) was also simulated for these three cases.

TABLE 1-2

Simulation Scenario Site Characteristics

SPILL SITE	SPILL LATITUDE (N)	SPILL LONGITUDE (W)	WIND DIRECTION	STABILITY COEFFICIENT	AIR TEMPERATURE	WATER TEMPERATURE	GEOGRAPHIC FILE NO.
New York Harbor (Perth Amboy)	40°30'40"	74°15'35"	315°	F	28°C	22°C	3611
New York Harbor (Coney Island)	40°31'25"	74°00'00"	5°	D	28°C	22°C	3612
Los Angeles Harbor (Long Beach)	33°42'34"	118°16'19"	0°	D	24°C	20°C	1611

For all spills: open waters
spill-to-shore separation = 300 meters
wind speed = 4 m/s (Perth Amboy runs: 2 m/s)
population sheltered = 0.50

TABLE 1-3

Results of Hazard Ranking

HAZARD CATEGORY	DESCRIPTION OF CATEGORY	CHEMICAL	HAZARD RANKING
Most Hazardous	Many thousands of casualties for all scenarios	Chlorine	1
Very Hazardous	Appreciable casualties for all scenarios	LNG	2
		LPG	2
		Methyl Bromide	2
Hazardous	Casualties only under extreme conditions (high atmospheric stability and close-in spills)	Ammonia	3
		Vinyl Chloride	4
		Pentane	4
		Methyl Chloride	5
		Toluene	5
		Ethyl Ether	6
Relatively Nonhazardous	No casualties or damage under any of the scenarios	Octane	7
		Dimethylamine	7
		Acetaldehyde	7
		Acrylonitrile	7
		Propylene Oxide	7

Chlorine is by far the most casualty-producing under all scenario conditions, even though it had the least quantity spilled. LNG, LPG and methyl bromide are ranked next, and no appreciable difference could be distinguished between them. The next six chemicals produced casualties only for one of the three scenarios. This was the scenario of highest atmospheric stability (F) and of closest-in spill (400 meters to closest downwind population cell). These six chemicals are ranked as shown based on the number of casualties. Finally, five chemicals produced no casualties under any conditions and were ranked as relatively nonhazardous. Of these, all are highly soluble except for octane, which is of low volatility.

Several observations are evident from an examination of the simulation results:

- As might be expected, soluble chemicals generally do not result in any casualties or damage. The spilled material rapidly goes into solution which reduces the vapor concentration at downwind cells below hazardous levels for both toxic and flammable materials. An exception to this is ammonia which is highly volatile and which was spilled in a relatively large quantity (10,000 m^3).

- For insoluble chemicals, the most hazardous are those that are highly volatile.

- The insoluble chemicals having the lower volatilities resulted in casualties only at Perth Amboy. This was due to the higher atmospheric stability (class F vs. class D) and the shorter distance between the population and the spill site at Perth Amboy versus the Coney Island or Los Angeles scenarios.

- For the most hazardous chemicals, the Coney Island scenario resulted in the most casualties. This was due primarily to the higher population density in the Coney Island area relative to the other two areas.

The spill simulations and their results are fully described and discussed in Chapter 5.

5. *Additional VM Program Modifications*

In the process of performing the four tasks summarized above, a number of imperfections and errors in the VM program were found and corrected. Of particular importance was the cleanup and clarification of the VM output tables to make the tables more understandable and easy to interpret for the UIM user. Also of major importance was the correction of a number of logic errors that were discovered during the running of the simulations in Task 4.

Listed below are the major cosmetic and logic modifications that were made to the VM program during the performance of the contract. All of these modifications have been incorporated in the latest version of the VM (i.e., cycle 15) which is available through SCOPE disk or on tape. See Chapter 6 for information on accessing the VM program.

a. *Modifications to VM output tables*

(1) Suppressed the "loader map" printout that precedes the VM output tables.

(2) Removed the time-incremented "radiation flux" tables that have not been used since the modification of the flash fire model.

(3) Provided for optional suppression of the vapor cloud concentration tables in ppm units. These tables are redundant since the concentration is also given in kg/m^3 units.

(4) Suppressed the ignition output table for toxic runs (the data are meaningless for toxic simulations).

(5) Printed the cloud dispersion coefficients, σ_y and σ_z, for plume as well as puff runs in the ignition output tables.

(6) Suppressed all damage tables for cells in which the values were all zero. For large Geographical files of the order of 400 cells, this reduces significantly the time and amount of computer printout.

b. *Logic corrections to the VM program*

(1) Corrected an error in the inside dosage computation. The dosage was originally given in ppm-sec and was corrected to ppm-min.

(2) Corrected an error in air temperature variable which was caused by mistyping of the variable's symbol.

(3) Corrected an error in the flash fire model that had resulted in the miscomputation of the size of the fireball due to use of incorrect vapor density.

(4) Revised the flash fire model to improve the accuracy by calling for the input of both the surface flame temperature and the flame speed.

(5) Corrected errors in the secondary fires flag assignment logic which caused the aborting of certain VM output tables under certain file status conditions.

(6) Corrected the logic error in subroutine PATH which assigned an incorrect model to some immiscible chemicals (such as ether).

(7) Revised the venting model to reduce the possibility of computational error (numerical overflow) under adiabatic tank conditions.

(8) Incorporated a bypass option which enables the user to circumvent the venting, spreading, and evaporation subroutines and go directly to the air dispersion model, Model C. This option supersedes the Path Override option when it is selected.

(9) Modified the integration time for toxic damage to the lesser of the total evaporation time or the user input "time the computations are to be made", VM field numbers 6001, 6004, or 6007. This enables the user to specify an evacuation time through specification of the time sequence variables. This is particularly important for chemicals with low volatility which take many hours or days to evaporate.

Chapter 2

USER INTERFACE MODULE

A. *INTRODUCTION*

The User Interface Module (UIM) is a computer program specifically designed for use by personnel with little or no computer experience. By interacting with the user in an easy-to-understand conversational mode, the UIM helps the user set up spill problems for the Vulnerability Model (VM) and then automatically runs the VM to simulate the spills. The UIM feeds data to and controls the VM, and serves as the interface between the VM and the user. In this capacity, the UIM performs six specific functions which assist the user in performing VM simulations.

First, using conversational prompts, the UIM acquires the inputs from the user that are needed to simulate the spill problem he is interested in. It only asks for those inputs that are necessary, thereby relieving the user of the worry about inputs that are not needed or that come from internal UIM or VM files. Approximately 150 inputs are needed for a VM simulation, but for a typical spill problem the user needs to supply only 30 or 40. Table 2-1 is a listing of all the inputs that the UIM requests of the user. In any given problem, a portion of these inputs would not be needed.

Second, the UIM provides information and instructional material that helps the user prepare the input values. Sufficient information is displayed to enable the user to prepare a simulation without the need for supporting documents or worksheets. This information is displayed only when requested by the user, so the experienced user is not held up by information statements he does not need.

Third, the UIM edits the inputs to check for alpha or numeric errors and then informs the user of the type of error.

Fourth, the UIM makes conversions, performs calculations, and provides data from its internal files necessary to complete the VM Input file. This file is then formatted in the proper VM computer format for submission to the VM. Actual submission of the run is made by the UIM following a user-supplied command to do so.

Fifth, the UIM informs the user of the chemicals for which spill simulations can be run, and the ports for which Geographical/Demographic files exist. Spill problems involving these chemicals and ports are the only problems that can be run through the UIM. Tables 2-2 and 2-3 present the chemicals and geographical files available in the UIM as of this writing. A current up-to-date listing of the available chemicals and ports is contained in the UIM program itself and in the UIM User's Operational Manual [6]. (If other chemicals or ports are desired, then either the UIM must be modified to include the proper data or the VM must be operated directly, i.e., not through the UIM.)

TABLE 2-1

Listing of User Inputs to UIM

INPUT NUMBER	INPUT VARIABLE	VALID ENTRIES
1	CHEMICAL CODE	AAD, ARL, ACN, AMA, BUT, BTN, CBT, CLX, DMA, EET, HDC, HCN, HFX, HDS, LNG, LPG, MTB, MTC, OAN, PTA, PHG, PRP, PPL, POX, SFD, TOL, VCM
2	CARGO TEMPERATURE	-200 to +300°C (-432 to +508°F)
3	TANK PRESSURE	(ATMOSPHERES)
4	TANK CAPACITY	(CUBIC METERS or THOUSANDS OF GALLONS)
5[a]	TANK HEIGHT	(METERS or FEET)
6	FRACTION OF TANK FILLED	0 to 1.00
7	HOLE DIAMETER	Must be >0 (METERS or FEET)
8[b]	HEIGHT OF CENTERLINE	(METERS or FEET)
9[c]	HEIGHT OF HOLE BOTTOM	(METERS or FEET)
10	SPILL LOCATION	1 (OPEN or STILL WATERS); 2 (FLOWING WATERS)
11	WATER TEMPERATURE	-4 to +49°C (25 to 120°F)
12[d]	CHANNEL WIDTH	(METERS or FEET)
13[d]	AVERAGE RIVER DEPTH	(METERS or FEET)
14[d]	AVERAGE RIVER VELOCITY	(METERS PER SECOND or FEET PER SECOND)
15[d]	TYPE OF RIVER BANKS	1 (CLEAN, SMOOTH); 2 (MODERATELY ROUGH); 3 (COARSE, DENSELY VEGETATED)
16	AVERAGE WIND SPEED	(METERS PER SECOND or FEET PER SECOND)
17	WIND DIRECTION	0 to 359 DEGREES
18	AIR TEMPERATURE	-40 to +49°C (-40 to +120°F)
19	ATMOSPHERIC STABILITY CODE	B (UNSTABLE); D (MODERATELY STABLE); F (STABLE)
20	DEGREES LATITUDE	00°00'00" to 89°59'59"
21	DEGREES LONGITUDE	00°00'00" to 179°59'59"
22	DISTANCE OF SPILL TO SHORE	(METERS or FEET)
23	TYPE OF DAMAGE	1 (TOXIC); 2 (POOL BURNING); 3 (FIREBALL); 4 (FLASH FIRE)
24	GEOGRAPHIC FILE	1611, 2211, 3611, 3612
25[e]	SECONDARY FIRES	YES or NO (only for Geographic files 2211 and 3611 presently)
26	FRACTION OF POPULATION SHELTERED	0 to .99
27[f]	BEGIN FIRST TIME SEQUENCE	(SECONDS)
28[f]	TIME INTERVAL FOR FIRST TIME SEQUENCE	(SECONDS)
29[f]	END FIRST TIME SEQUENCE	(SECONDS)
30[f]	BEGIN SECOND TIME SEQUENCE	(MINUTES)
31[f]	TIME INTERVAL FOR SECOND TIME SEQUENCE	(MINUTES)
32[f]	END SECOND TIME SEQUENCE	(MINUTES)
33[f]	BEGIN THIRD TIME SEQUENCE	(MINUTES)
34[f]	TIME INTERVAL FOR THIRD TIME SEQUENCE	(MINUTES)
35[f]	END THIRD TIME SEQUENCE	(MINUTES)

[a]Top-to-bottom height. [b]Hole's centerline above waterline. [c]Hole's bottom above tank bottom. [d]Not used if open waters are specified for item 10. [e]Not used if a toxic damage code is specified for item 23. [f]Default sequence used if requested.

TABLE 2-2. Chemicals in UIM

CHEMICAL	CODE	TYPE OF HAZARD*
Acetaldehyde	AAD	F
Acrolein	ARL	T,F
Acrylonitrile	ACN	T
Ammonia (anydrous)	AMA	T
Butane	BUT	F
Butylene	BTN	F
Carbon tetrachloride	CBT	T
Chlorine	CLX	T
Dimethylamine	DMA	F
Ethyl ether	EET	F
Hydrogen chloride	HDC	T
Hydrogen cyanide	HCN	T
Hydrogen fluoride	HFX	T
Hydrogen sulfide	HDS	T,F
Liquefied natural gas	LNG	F
Liquefied petroleum gas	LPG	F
Methyl bromide	MTB	T
Methal chloride	MTC	F
Octane	OAN	F
Pentane	PTA	F
Phosgene	PHG	T
Propane	PRP	F
Propylene	PPL	F
Propylene oxide	POX	T,F
Sulfur dioxide	SFD	T
Toluene	TOL	T,F
Vinyl chloride	VCM	F

*Principal hazard codes are: T=toxic, F=flammable.

TABLE 2-3. Available Geographical Files

PORT CITY	FILE NAME	UIM CODE
New York, Perth Amboy area	GEONY4	3611
New York, Coney Island area	GEONY6	3612
New Orleans	GEONO1	2211
Los Angeles	GEOLA1	1611

Sixth, the UIM provides for storage of previous VM Input files prepared by the user. When similar problems are to be run, the user can call for these files and make changes to them rather than create entirely new files; this greatly reduces the file preparation time.

B. *DESCRIPTION OF THE UIM*

1. *Introduction*

In structure, the UIM consists of two programs: (1) UIML, an *unabridged* program which accommodates the beginner or occasional user, and (2) UIMS, an *abridged* program which accommodates experienced users who are more conversant with computers and who are sufficiently conversant with the data needs of the VM so as not to need detailed information on the inputs.

Each of the programs is further divided into two branches: a branch for creating a new Input file and a branch for using an Input file previously created and saved. The latter branch is a time-saver when the user is interested in running a series of similarly structured problems which differ in only one or two parameters. An edit routine enables the user to make changes to any of the inputs in the old file and resubmit the run. Figure 1-1 in the Introduction and Summary Chapter 1 illustrates the basic structure of the UIM and a detailed UIM flowchart is presented in Appendix B.

2. *Unabridged Program (Detailed or Long Version)*

In operation, the user of the UIM is asked initially for his/her name. This is for file-management purposes. Then, the user is asked whether or not he wants to use the unabridged (long) version of the UIM; if the response is negative, the abridged program is then accessed. The differences between the two programs consist of quantity of prose and additional information options. In the long version, each needed data input is explained prior to the actual request for the input value. The input requests are arranged by groups, and there is a preamble to each group, wherein the user is asked whether or not further information is desired. If the response is affirmative, then several paragraphs of additional explanatory material, usually consisting of "typical values" lists or a fuller description of the physical nature of the group of inputs, are presented. This explanatory material is presented in Appendix B of the UIM User's Operational Manual.

3. *Abridged Program (Short Version)*

The short version was created to satisfy the needs of a more experienced user, who perhaps has resorted to the detailed version several times previously and is sufficiently conversant with the data input explanations so as to not wish to be presented with the textual material each time a file needs to be built. The short version consists of a series of brief, one-line prompts for data, with the cursor (or printhead) remaining on the

line of the prompt each time. No access to the informational passages is granted, and at no time may the user switch back to the detailed version without stopping the program and then restarting (and vice versa).

4. *Internal Error Checks*

Each version makes the same data range checks for file integrity. If a certain alphabetic response is solicited, it must be entered or the solicitation will be repeated until a satisfactory answer is received. Numeric data must conform to any physical constraints; for instance, latitude(longitude) data must be not greater than 89(179) degrees, 59 minutes, 59 seconds. However, most of the numeric inputs are selectable at the discretion of the user, with no range checks performed.

Certain errors made in inputs when under control of the abridged version will produce error messages that come from the detailed version, but generally only the message "ERRONEOUS INPUT" will be printed. The detailed version will generally present explanations as to the nature of the error and a lengthier request for reentry of the datum.

Each version is structured so as to solicit values only for pertinent inputs. For instance, if a toxic run is requested, the input requesting secondary fires choice will be suppressed. Thus the full set of possible solicitations may not be presented depending upon the spill scenario contemplated by the user.

5. *Listing and Naming of Input File*

Both programs of the UIM flow identically after the last possible input has been entered. A listing of the file created by the user is presented* with its internally generated name, using the units of measurement specified by the user.

6. *Use of Old Input Files*

As mentioned previously, the user does not have to create a file each time by answering all of the possible questions sequentially. If a previously UIM-created file exists on disk in the account, and if only a few changes need to be made to it to create a file for a new problem for the VM, the user may opt to reenter this file automatically and save some time and effort in the process.

Immediately after selecting the UIM version desired, the user is asked whether an old or a new file is to be built. If the response is "NEW", sequential input solicitation, starting with the type of measurement units, is initiated as described above. However, if the user selects "OLD", the

*The short version program provides the user the option to view the inputs or to skip the listing and go directly to the editing branch, whereas the long version automatically presents the listing.

program then asks for the name of the old file to be loaded in. The user enters the correct six-character UIM file name, and the program then pulls the file off the disk and loads it. The result of a successful loading is the same as that for completion of the "new file" branch—a listing of the complete file by input.

7. Changes to an Input File (Editing an Input File)

After the listing is completed, the user is asked if any changes (edits) are to be made to the file. If an affirmative response is received, the program then prompts for the line number of the input sought to be changed (from the listing), and then a prompt for the new value is issued. If the detailed program was previously selected, a full prompt is given, and the option for the information statement pertinent to the input is given. The short version presents a brief prompt, with no choice for additional information.

The editing branch is complete in the sense that, if a chain of dependent data values has one of its inputs modified, all of the other values that will be affected will automatically be processed properly. For instance, if the user has a file loaded in with information on river velocity, depth and width, and during editing decides to change the spill environment to a nonriver (open water) scenario, the inputs pertinent to the original river scenario will also be taken out of the edited version. If the opposite situation occurs, the user will be asked for data needed to complete the river scenario automatically before edit control is returned to the user.

8. Completion of the Input File

The user is prompted for more changes after each successful edit. At this time, an entry of the word "LIST" will generate the updated, most current version of the original file's contents. If the user wishes to depart from the edit phase of the program, a negative response to the solicitation for more changes must be entered.

9. Readying the Input File for VN Simulation

The next question asked will be whether the user wishes to run a VN simulation using the current file. If the response is affirmative, the current file will be arranged internally to fit the format requirements of the VN and a temporary file will be generated; otherwise, no temporary file will be made and the VN will not be run.

10. Saving an Input File

Finally, the user is asked if the current file is to be saved on disk. Automatic storage is not a feature of this program so as not to create a disk-cluttering situation. However, this solicitation has to be used carefully. If the user were to have loaded an old file in and made no changes

to it, then it would be pointless to resave it since old files are always returned unchanged to disk after each run of the program, so the UIM will not honor this request in this situation. However, if the old file was modified, the current file (old file plus modifications) will be saved if so desired. If the file was built from scratch (a new file), it will similarly be saved if so desired.

11. Terminating the UIM and Executing the VM Simulation

If a VM simulation based upon the current file is desired, i.e., if an affirmative response to the UIM query for running the VM is entered, a flag will be set and automatic engagement of the VM submission job stream will occur, with about a 20-second delay before the name of the job is printed. If no simulation is desired, the program will simply terminate and clear all local files from the workspace.

12. Recalling the UIM Program To Prepare Another Input File

After the UIM program terminates, the user may call it back by simply typing in the command "-RUIM" again and starting over. If the generated file was not saved, it will not be retrievable; if it has been saved, then the user may operate on it or any other UIM-saved file at his discretion.

C. *UIM PROGRAM DOCUMENTATION*

1. General

In this section, the infrastructure is described for the benefit of those wishing to understand the programming logic. Also, the procedure files and jobstreams which are linked to the UIM are described.

2. The UIM Programs

The UIM is actually two similarly constructed programs. The short version is named UIMS; the long version is UIML. It is written in CDC's version of BASIC under NOS, and is retrieved from disk before execution to the user's workspace. The following is a technical description of the common programming philosophy used to construct the modules.

All user entries and applicable internally stored data are arranged in the Z matrix, which is set up in a row-by-column fashion as Z(a,b) where "a" corresponds to the form of data per data entry "b". Specifically, if a=1, Z(a,b) will be the VM field identification number for the variable corresponding to b; if a=2, Z(a,b) will be the actual (raw) user input, in

alphabetic form, or if numeric, in MKS or British units; if a=3, Z(a,b) will be the converted user input value, i.e., the numeric value converted to the VM-required cgs (centimeter-gram-second) units system.

The major data block stored in the UIM is the C3(a,b) chemical properties matrix, which holds 18 different chemical properties per chemical for 27 chemicals. The chemical properties are those needed for simulation but not retrievable from the master Chemical Properties file accessed by the VM. The chemical code itself is the basis for setting the value of "a" in the C3 matrix; "a" is determined by a short lookup routine that checks to be sure that the three-letter code is one for which the UIM can provide chemical properties.

The program has been wrapped around itself as much as possible to reduce excessive coding by usage of a set of flags that control program flow. The flags are as follows:

- F1 — units flag; 1=British system, 2=MKS system
- F2 — chemical code flag; 0=invalid, 1=valid
- F4 — editing branch flag; 0=editing branch not in use, 1=editing branch in use
- F5 — file type flag; 0=new file, 1=old file
- F6 — version type flag; 0=detailed(long), 1=abridged(short)
- F8 — call to filename generator flag; 0=no call has been made, 1=call has been made (and a name has been generated)
- G4 — geographical file code validation flag; 0=invalid geographic file code (query for a new one), 1=valid code (pull the file off of disk)
- B3 — time sequences source flag; 0=time sequences have been calculated by program, 1=time sequences were supplied by user.

There are several string variable names used by the UIM; the key ones are listed below:

- A1$ — stores the 26 letters of the alphabet
- A2$ — temporary location of randomly generated six-letter filename
- A3$ — stores the valid three-letter chemical codes as a string
- B3$ — stores the YES/NO response to solicitation to change the internally calculated time sequences (if any)
- D1$ — command string variable for communicating with NOS
- D$ — holds the name of the file currently being operated on
- E$ — variable to which the name of an old file is passed if if the user opts to save the edited version of the old file (on disk)

- F$ — holds name of geographical file stored on disk corresponding to the input geographical file code
- G$ — holds name of the corresponding (to F$) secondary fires file if it exists and if a secondary fires run is requested by the user
- K$ — controls flow pertinent to whether a detailed or abridged version run is requested
- L1$ through L7$ — hold latitude (L1$ & L2$ & L3$ & L7$) and longitude (L4$ & L5$ & L6$ & L7$) substring values broken down by degrees, minutes, seconds, and decimal
- L$(1),L$(2) — concatenated substrings from Ln$ series for latitude and longitude, as DDDMMSS.
- M1$ — holds the valid three-letter chemical code
- M5$ — holds YES/NO response to prompt for consideration of secondary fires sources; used with G$ to produce a disk-retrieval command if appropriate
- M9$ — stores the selected atmospheric stability code
- U$ — stores the file source (old or new)
- W$ — general alphanumeric input variable
- Y2$ — holds YES/NO response to prompt to run a VM simulation.

There are four levels of file status permissible in the UIM. Level 1 is for a new UIM file; Level 2 is for an old UIM file; Level 3 is for an edited old UIM file; and Level 4 is for the VM input file (VMINPUT). Figure 2-1 on page 2-10 lists a typical disk-saved UIM-created file that could have been produced out of Levels 1, 2, or 3, given the randomly generated name APAPAP. For comparison, Figure 2-2 on page 2-11 lists APAPAP in the VM-ready form, the Level 4 file VMINPUT. Functions specific to CDC BASIC that are used include RND (produce a random number from zero to one), DAT$ (produce the date), FILE (control file disposition), CLOSE (similar to FILE), GET and SAVE (NOS commands).

The VM field numbers, associated variable descriptions, and corresponding Z matrix second-subscript values are presented in Table 2-4 on pages 2-12 and 2-13.

```
UIM INPUT   CLX AT PERTH AMBOY                          79/06/22,

1001 CLX              ,CLX,
  10 3611               300.00
  20                  2
   0                  0
2001 9.0000E+07            90.00
2002   500.0            5.00
2003      .0             .00
2004  -33.00           -33.00
2005 1.0000E+06         1
2006 0.
2007 1.2560E+08        .98
2008 2.0000E+02         2.00
2011  .0000E+00
2015  100.               1.00
2016  200.              2.00
2017 6.               F,
2018            2.    1
2022            1.
2023  22.00            22.00
2033     .000
2028            1.
2029            0.
1019    0.
2036  -33.00
2043      1.000
2046  .0
2054   28.00            28.00
2058 325.00           325.0
3004            0.    0
5002            0.
5003            0.    1
5004            1.      NO,
5006            0.
5019   0.
5020  999.0
5030    2.6400
5031  -36.4500
5032    3.1300
5033   -2.4000
5034    2.9000
5035    3.4000
5036  100.0000
5038  .50              .50
6001    0.                0.
6002    0.                0.
6003    0.                0.
6004   40.               40.
6005   40.               40.
6006    1.                1.
6007    0.                0.
6008    0.                0.
6009    0.                0.
6010 403040.          ,403040.    ,
6011 0741535.         ,0741535.   ,
```

FIGURE 2-1. List of a Typical UIM Output File, Named APAPAP

```
CLX AT PERTH AMBOY      79/06/27.
1001CLX
2001 .9000E+08
2002   500.0
2003      .0
2004  -33.00
2005 .1000E+07
2006 0.
2007 .1256E+09
2008 .2000E+03
2011 .0000E+00
2015 .1000E+03
2016 .2000E+03
2017 6.
2018 2.
2022 1.
2023  22.00
2033    .0000
2028 1.
2029 0.
1019    0.
2036 -33.00
2043 .1000E+01
2046  .0
2054   28.00
2058 325.00
3004 0.
5002 0.
5003 0.
5004 1.
5006 0.
5019   0.
5005  0.
5030    2.640
5031  -36.450
5032    3.130
5033   -2.400
5034    2.900
5035    3.400
5036  100.000
5038  .50
6001    0.
6002    0.
6003    0.
6004   40.
6005   40.
6006    1.
6007    0.
6008    0.
6009    0.
6010 403040.
6011 0741535.
```

FIGURE 2-2. VMINPUT, Created from APAPAP

TABLE 2-4

VM Input File Prepared Through UIM

VM FIELD NUMBER	DESCRIPTION OF INPUT	SOURCE OF INPUT	Z MATRIX n-value (Z(i,n))
1001	Chemical Code	User - Question #1	--
1019	60% of Maximum Flame Temperature, °C	UIM Chemical Properties File	140
2001	Tank Capacity	User - Question #4	4
2002	Tank Height	User - Question #5	5
2003	Height of Bottom of Hole	User - Question #9	9
2004	Cargo Temperature	User - Question #2	2
2005	Tank Pressure	User - Question #3	3
2006	Tank Thermal Conditions	UIM Chemical Properties File	135
2007	Initial Mass of Cargo	Computed by UIM from Other Inputs	from 6,4,136
2008	Hole Diameter	User - Question #7	7
2011	Product of Density times Heat Capacity	UIM Chemical Properties File	137
2015	Height of Hole's Centerline	User - Question #8	8
2016	Wind Speed	User - Question #16	16
2017	Atmospheric Stability	User - Question #19	19
2018	Channel or Radial Spill	User - Question #10	10
2020	Channel Width	User - Question #12	12
2022	Heat Transfer Conditions, set to 1	UIM Chemical Properties File	138
2023	Water Temperature	User - Question #11	11
2028	Spill Environment	User - Question 10	101
2029	Duration of Discharge Flag, set to 0	--	--
2033	Flame Speed	UIM Chemical Properties File	139
2036	Temperature of Liquid Discharged	Equal to Cargo Temperature	103
2043	Diffusion Coefficient	UIM Chemical Properties File	141
2044	Depth of River	User - Question #13	13
2045	Width of River	User - Question #12	104
2047	Velocity of River	User - Question #14	14
2052	Manning Roughness Factor	User - Question #15	15
2054	Air Temperature	User - Question #18	18
2058	Wind Direction	User - Question #17	17
3004	Secondary Fire Source Indicator	User - Question #25	25
5002	Miscibility Indicator	UIM Chemical Properties File	143

(continued)

TABLE 2-4 (concluded)

VM Input File Prepared Through UIM

VM FIELD NUMBER	DESCRIPTION OF INPUT	SOURCE OF INPUT	Z MATRIX n-value (Z(i,n))
5003	Flammability Indicator	User - Question #23	23
5004	Toxicity Indicator	User - Question #23	105
5005	Liquid Toxicity Indicator, set to 0	UIM Chemical Properties File	146
5006	Type of Ignition	User - Question #23	106
5019	Moles of Oxygen	UIM Chemical Properties File	147
5020	Flashpoint	UIM Chemical Properties File	155
5030	Toxicity Exponent	UIM Chemical Properties File	148
5032	Coeff A - Lethality	UIM Chemical Properties File	149
5033	Coeff B - Lethality	UIM Chemical Properties File	150
5034	Coeff A - Injury	UIM Chemical Properties File	151
5035	Coeff B - Injury	UIM Chemical Properties File	152
5036	Irritation Threshold	UIM Chemical Properties File	153
5037	Coefficient of Ingestion	UIM Chemical Properties File	154
5038	Fraction of Population Sheltered	User - Question #26	26
6001	Time Begin Loop 1	*User - Question #27	27
6002	Time End Loop 1	*User - Question #28	28
6003	Time Interval Loop 1	*User - Question #29	29
6004	Time Begin Loop 2	*User - Question #30	30
6005	Time End Loop 2	*User - Question #31	31
6006	Time Interval Loop 2	*User - Question #32	32
6007	Time Begin Loop 3	*User - Question #33	33
6008	Time End Loop 3	*User - Question #34	34
6009	Time Interval Loop 3	*User - Question #35	35
6010	Latitude	User - Question #20	20
6011	Longitude	User - Question #21	21

*These inputs are also computed by the UIM and will be used if the user so chooses.

3. *UIM-Associated Files and Jobstreams*

The UIM is accessed either directly or by recourse to a procedure file named RUIM ("Run-UIM") which automatically selects the user-desired UIM version, and then tests for the possible UIM file outputs to set up and run a VM submission. Usage of RUIM is recommended for routine runs of the VM; it is not useful when display plot files are desired (since the UIM does not set KPLOT), when bypass or ppm table suppression runs are contemplated, or when updates are to be included in a VM run, unless modifications to the called jobstreams are also made. RUIM is presented as Figure 2-3. Note that it is set up to call either of two jobstreams, RUNUIM or RUNUIM2, and that it clears all files from the workspace after a successful submission, thus allowing for multiple runs during a single session.

RUIM initially calls UCLECT, a short procedure file which retrieves from disk the version of the UIM corresponding to the user's input to a YES or NO solicitation. At present, the UIM long version is not storable as an object module due to its great length, so it must be compiled each time it is used. A compilation plus execution of UIML generally requires about 12 SBU's of system resources, which is $5.40 under current rates (the short version generally requires 7.5 SBU's or $3.38).

RUIM eventually calls jobstream RUNUIM (if a secondary fires run is to be performed) or RUNUIM2 (in the opposite case). RUIM, UCLECT, RUNUIM, and RUNUIM2 are listed as Figures 2-3 through 2-6. The flowchart for the UIM programs as they are embedded in RUIM is presented in Appendix B along with a listing of the respective source codes.

D. *DATA PREPARATION FOR UIM CHEMICAL PROPERTIES FILE*

As previously mentioned, the major data block stored in the UIM is the Chemical Properties file which holds 18 different properties for each chemical, of which there are currently 27. These properties are those needed for VM simulation but not retrievable from the VM Chemical Properties file.

Table 2-5 presents the data currently contained in the file for the 27 chemicals. These data were obtained through a literature search or consultation with experts. As noted, some data were unavailable and default values are being used until data can be developed.

The probit coefficients for toxic chemicals are a key part of the UIM Chemical Properties file. Appendix C discusses the derivation of the probit coefficients for all of the toxic chemicals, including the checking and correction of the coefficients for probits previously derived.

```
00090 RFL,40000.
00100 GET,UCLECT.
00101 LDC,0,UCLECT,,1,  .
00102 IF (FILE(UIMS,LO).EQ.1)GOTO,20BT.
00103 LDC,0,UIML,,1,  .
00104 GOTO,2JMP.
00105 20BT,LDC,0,UIMS,,1,  .
00120 2JMP, IF (FILE(VMINPUT,LO).EQ.0)EXIT.
00130 IF (FILE(GEONY4,LO))GOTO,1A.
00140 IF (FILE(GEONY6,LO))GOTO,1B.
00150 IF (FILE(GEOLA1,LO))GOTO,1C.
00160 IF (FILE(GEOLA2,LO))GOTO,1D.
00170 IF (FILE(GEONO1,LO))GOTO,1E.
00180 1A,RENAME,GEOG=GEONY4.
00181 IF (FILE(SECNY4,LO).EQ.0) GOTO,2SUB.
00182 RENAME,SFIRE=SECNY4.
00190 GOTO,2SUB.
00200 1B,RENAME,GEOG=GEONY6.
00210 GOTO,2SUB.
00220 1C,RENAME,GEOG=GEOLA1.
00230 GOTO,2SUB.
00240 1D,RENAME,GEOG=GEOLA2.
00250 GOTO,2SUB.
00260 1E,RENAME,GEOG=GEONO1.
00265 IF (FILE(SECFRE,LO).EQ.0)GOTO,2SUB.
00270 RENAME,SFIRE=SECFRE.
00280 GOTO,2SUB.
00290 2SUB,IF (FILE(SFIRE,LO).EQ.0)GOTO,2U.
00300 GET,RUNUIM.
00310 SUBMIT,RUNUIM,ST=ECZ,T.
00320 GOTO,1END.
00330 2U,GET,CHEAPVM.*
00340 SUBMIT,CHEAPVM,ST=ECZ,T.
00350 1END,CLEAR.
```

*Since renamed RUNUIM2

FIGURE 2-3. Procedure RUIM

```
00005 PRINT
00015 PRINT ≠DO YOU WANT TO USE THE DETAILED VERSION OF THE UIM?≠
00025 PRINT ≠(TYPE IN A YES OR A NO ANSWER--)≠
00035 INPUT A$
00045 IF A$=≠YES≠ OR A$=≠NO≠ THEN 75
00055 PRINT ≠YOUR ANSWER MUST BE EITHER YES OR NO--PLEASE RETYPE IT.≠
00065 GOTO 35
00075 IF A$=≠YES≠ GOTO 105
00085 FILE ≡1: ≠GET.UIMS≠
00095 GOTO 115
00105 FILE ≡1: ≠GET.UIML≠
00115 CLOSE ≡1
00125 STOP
00135 END
```

FIGURE 2-4. Program UCLECT

```
LIST

 79/06/11. 14.11.10.
PROGRAM   RUNUIM

/JOB
SECFIVM,NT1,CM310000,T100,P2.
USER([redacted])
PROJECT,*MRI*.
REWIND(OUTPUT)
ROUTE,OUTPUT,UN=C,TID=UN,DC=PR,DEF.
HEADING.X1PLS HOLD
HEADING.X U S C G
HEADING.X1 VUL. MOD.
HEADING.X   OUTPUT
HEADING,,1.
COPYBR,,TAPE15.
COPYBR,,SECFRE.
REWIND,SECFRE.
REWIND,TAPE15.
REQUEST,VMTAPE,NT,PE,NORING,CT=PU,ID=USCG,VSN=0S1828.
COPYBF,VMTAPE,TAPE22.
COPYBF,VMTAPE,TAPE9.
COPYBF,VMTAPE,TAPE10.
COPYBF,VMTAPE,TAPE14.
COPYBF,VMTAPE,PH1BIN.
COPYBF,VMTAPE,PH2BIN.
REWIND(VMTAPE,TAPE22,TAPE9,TAPE10,TAPE14,PH1BIN,PH2BIN)
RETURN,VMTAPE.
MAP,OFF.
LDSET(PRESET=ZERO)
PH1BIN.
REWIND(TAPE12,TAPE13,TAPE14)
PH2BIN.
/EOR
/NOSEQ
/PACK
/READ,GEOG
/EOR
/READ,SFIRE
/EOR
/READ,VMINPUT
/EOR
/EOF
READY.
```

FIGURE 2-5. Program RUNUIM

```
READY.
LIST

 79/06/11. 14.08.46.
PROGRAM   RUNUIM2

/JOB
FASTVM,NT1,CM310000,T100,P2.
USER([redacted]
PROJECT,*MRI*.
REWIND(OUTPUT)
ROUTE,OUTPUT,UN=C,TID=UN,DC=PR,DEF.
HEADING.X1PLS HOLD
HEADING.X U S C G
HEADING.X1 VUL. MOD.
HEADING.X   OUTPUT
HEADING,,1.
COPYBR,,TAPE15.
REWIND,TAPE15.
REQUEST,VMTAPE,NT,PE,NORING,CT=PU,ID=USCG,VSN=0S1828.
COPYBF,VMTAPE,TAPE22.
COPYBF,VMTAPE,TAPE9.
COPYBF,VMTAPE,TAPE10.
COPYBF,VMTAPE,TAPE14.
COPYBF,VMTAPE,PH1BIN.
COPYBF,VMTAPE,PH2BIN.
REWIND(VMTAPE,TAPE22,TAPE9,TAPE10,TAPE14,PH1BIN,PH2BIN)
RETURN,VMTAPE.
MAP,OFF.
LDSET(PRESET=ZERO)
PH1BIN.
REWIND(TAPE12,TAPE13,TAPE14)
PH2BIN.
/EOR
/NOSEQ
/PACK
/READ,GEOG
/EOR
/READ,VMINPUT
/EOR
/EOF
READY.
```

FIGURE 2-6. Program RUNUIM2

TABLE 2-5. UIM Chemical Properties Matrix

CHEMICAL NAME / UM FIELD CODE	CHEM CODE 1001	TANK CONDITION (a) 2006	(LIQUID) DENSITY, g/cm³ (b) 2007	DUMMY DATA (c) (2021)	FLAME SPEED, cm/s 2033	SURFACE FLAME TEMP., °C (d) 1019	H_2O DIFFUS. COEFF., cm^2/s (e) 2043	MISCIBILITY FLAG (f) 5002	FLAMMABILITY FLAG (f) 5003	TOXICITY FLAG (f) 5004	MOLES OF O_2/MOLE OF FUEL 5019	PROBIT COEFFICIENTS: EXPONENT 5030	T1A 5031	T1B 5032	T2A 5033	T2B 5034	T3A 5035	COEFF. OF INGESTION (e) 5036	FLASH-POINT, °C (g) 5020
Acrolein	ARL	0	0.841		350*	1100*	1	1	1	1	4	1.00	-9.93	2.049	0	0	0.26	100	-26
Anhydrous Ammonia	AMA	0	0.682 [-33]		0	0	1	1	0	1	2	1.36	-28.33	2.27	0	0	100	100	999
Carbon Tetrachloride	CBT	0	1.59		0	0	1	0	0	1	0	2.50	-6.27	0.408	0	0	1000*	100	999
Chlorine	CLX	0	1.42		0	0	1	0	0	1	0	2.64	-36.45	3.13	-2.40	2.9	3.4	100	999
Hydrogen Cyanide	HCN	0	0.699 [22]		0	0	1	1	0	1	0	1.43	-29.4	3.008	0	0	20	100	999
Hydrogen Chloride	HDC	0	1.191 [-90]		0	0	1	1	0	1	0	1.00	-16.85	2.104	0	0	10	100	999
Hydrogen Sulfide	HDS	0	1.374 [-61]		350*	1100*	1	1	1	1	1.5	1.43	-31.34	3.008	0	0	70	100	-5
Hydrogen Fluoride	HFX	0	0.992 [20]		0	0	1	1	0	1	0	1.00	-25.87	3.354	2.797	2.9	52	100	999
Liquefied Natural Gas	LNG	0	0.415 [-161]		338	1069	1	0	1	0	2	1.00	0	0	0	0	0	100	-151
Methyl Bromide	MTB	0	1.68		0	0	1	0	0	1	0	1.00	-56.81	5.27	0	0	1000*	100	999
Phosgene	PHG	0	1.89		0	0	1	0	0	1	0	1.00	-19.27	3.686	0	0	5	100	999
Sulfur Dioxide	SFD	0	1.434		0	0	1	1	0	1	0	1.00	-15.67	2.10	0	0	5	100	999
n-Butane	BUT	0	0.58		379	1081	1	0	1	0	6.5	1.00	0	0	0	0	0	100	-60
s-Butane	BTS	0	0.60 [20]		432	1118	1	0	1	0	6	1.00	0	0	0	0	0	100	-79
Ethyl Ether	EET	0	0.71 [20]		350*	1079	1	0	1	0	6	1.00	0	0	0	0	0	100	-45
Liquefied Petroleum Gas	LPG	0	0.35		350	1100	1	0	1	0	5.5	1.00	0	0	0	0	0	100	+69
n-Octane	OAN	0	0.702 [20]		350*	1078	1	1	1	0	12.5	1.00	0	0	0	0	0	100	-40
n-Pentane	PTA	0	0.63 [20]		385	1077	1	1	1	0	8	1.00	0	0	0	0	0	100	-49
Propane	PRP	0	0.53		390	1130	1	1	1	0	5	1.00	0	0	0	0	0	100	-53
Propylene	PPL	0	0.52		350*	1112	1	1	1	0	4.5	1.00	0	0	0	0	0	100	-108
Vinyl Chloride Monomer	VCM	0	0.91 [20]		350*	1100*	1	1	1	0	2.5	1.00	0	0	0	0	0	100	-78
Acrylonitrile	ACN	0	0.81 [20]		0	0	1	1	0	1	4.5	1.43	-29.42	3.008	0	0	1000*	100	999
Propylene Oxide	POX	0	0.86		350*	2411	1	1	1	1	4	2.0	-7.415	0.509	0	0	1000*	100	-37
Toluene	TOL	0	0.87 [20]		350*	1130	1	0	1	1	9	2.5	-6.794	0.408	0	0	1000*	100	+7.2
Acetaldehyde	AAD	0	0.78 [18]		350*	1100*	1	1	1	0	2.5	2.75	0	0	0	0	1000*	100	-38
Dimethylamine	DMA	0	0.68		350*	1100*	1	1	1	0	4.25	2.75	0	0	0	0	1000*	100	-48
Methyl Chloride	MTC	0	0.92		350*	1100*	1	0	1	0	1.5	2.75	0	0	0	0	1000*	100	0

(a) 0 = adiabatic; 1 = isothermal.
(b) Taken at 0°C unless indicated otherwise by bracketed temperature (°C).
(c) For future UIM Chemical Properties file expansion.
(d) Or 60% of maximum (core) flame temperature.
(e) Not currently needed; category included for possible future UIM applications.
(f) 1 = has this property; 0 = converse.
(g) 999 = nonflammable (or insufficiently flammable).

*Assumed values used in lieu of actual values until they become available.

E. USER DOCUMENTATION

Instructions for using the UIM are provided in the UIM User's Operational Manual [6]. This manual describes the function and structure of the UIM, presents basic operating instructions, gives examples of UIM operating sessions, and describes and interprets the VM output.

Chapter 3

VM GRAPHICAL DISPLAYS

A. *INTRODUCTION*

To enhance the utility of the VM simulations, a series of graphical displays have been developed which display on a CRT terminal or plotter the extent of the personnel and structural damage associated with toxic, flammable, or explosive chemical spills. By use of the graphical displays, the spatial and temporal characteristics of the hazards become more readily comprehensible, and the analyst is provided with a more descriptive summary of the progress of the hazardous event.

The set of display plots (frames) that have been developed for a particular spill simulation consists of:

- A family of curves showing the constant concentration contour lines for the atmospheric transport of a hazardous vapor, based on lower ignitable limit or irritation threshold.
- Zones of expected fatalities, disaggregated by fractional damage contours.
- Zones of expected injuries, disaggregated by fractional damage contours.
- Zones of structural damage.

The contour lines are superimposed over a schematic map of the corresponding cell (vulnerable resource) centers to further clarify the VM results.

Currently the plots can be displayed on Tektronix-type CRT terminals (Models 4010 or 4012) or plotted on CALCOMP hard copy plotters. Construction of the VM plotting package has been performed in a modular fashion, and the particular procedure files that inform the computer of terminal status can be easily rearranged to accommodate different brands of CRT terminals or hard copy plotters.

When using the interactive display programs, the user is granted the option to alter some of the original scenario features, such as wind direction and spill location, as a means of analysing the same basic problem parametrically without going to the expense of further VM runs.

All of the plotting data is generated by the VM, which has been modified and to which seven new subroutines have been added. The generated plotting data are stored on a disk file. X,y plotting data are generated for the following variables:

- irritation threshold vapor concentration—puff model
- irritation threshold vapor concentration—plume model
- lower flammability limit vapor concentration—puff model
- lower flammability limit vapor concentration—plume model
- lethality from toxicity, outdoors—puff model
- lethality from toxicity, outdoors—plume model

- nonlethal toxic injury, outdoors—puff model
- nonlethal toxic injury, outdoors—plume model
- lethality from flash fire
- nonlethal injury from flash fire
- lethality from explosion peak overpressure
- nonlethal injury from overpressure
- structural damage

All data are displayed on a display which shows the spill site and the relevant cell centers. For the irritation threshold and the lower flammability limit associated with the puff model (variables 1 and 3), x,y contours are generated as a function of time (i.e., for a progression of time steps) so the user can see how the puff progresses with time. For all the remaining variables, time-independent envelopes are generated which show the regions affected. For all the lethality variables and for the structural damage variable, each display consists of several envelopes corresponding to several levels of lethality or damage presented as percent deaths or percent buildings destroyed.

All the plotting data generated in the VM are stored in a direct-access disk file which is saved under a system-given name. The user can retrieve the data for plotting using this name.

Three programs for plotting have been written which are independent of the VM. The program TOXDISP displays all curves relevant to toxic casualties; program FIRDISP displays all curves relevant to fire casualties; program EXPDISP displays all curves relevant to explosion casualties.

B. DERIVATIONS

The data generated are based upon the equations derived in the previous VM reports [1-5]. These equations are:

- vapor dispersion equations (3-1) and (3-2) (ref. [1])
- explosion equations (4-4) to (4-6) (ref. [1])
- flash fire equation (4-15) (ref. [5])
- toxic dose equations (2-6) and (2-7) (ref. [5])
- probit equation (6-1) (ref. [1])

These equations are rearranged to express the dependent variable y in terms of x as:

$$y = f(x) \tag{3-1}$$

Note that the vapor dispersion coefficients are functions of x only. The details of the derivations are presented in the following subsections entitled:

- Constant Vapor Concentration Contour
- Constant Toxic Casualty Contour, Outdoors
- Thermal Damage from Flash Fire Model
- Damage from Explosion

1. *Constant Vapor Concentration Contour*

(a) Puff Model

For the puff model, the vapor concentration at some point (x,y,z) at time t is given by:

$$C = \frac{2M}{(2\pi)^{3/2}\sigma_x\sigma_y\sigma_z} \exp\left[-\frac{(x-Ut)^2}{2\sigma_x^2} - \frac{y^2}{2\sigma_y^2} - \frac{z^2}{2\sigma_z^2}\right] \tag{3-2}$$

where:

C = vapor concentration (kg/m^3)

$\sigma_x, \sigma_y, \sigma_z$ = dispersion coefficients in x-, y-, z-directions (m)

M = mass of vapor liberated (kg)

U = wind speed (m/s)

x, y, z = Cartesian coordinates with the origin at the source of the air dispersion material; the wind is assumed to blow toward the positive x-direction, and the crosswind coordinate is y.

When the vapor concentration C is equal to a given value C_L, then equation (3-2) can be written as:

$$\frac{(x-Ut)^2}{\sigma_x^2} + \frac{y^2}{\sigma_y^2} + \frac{z^2}{\sigma_z^2} = 2\,\ln\left[\frac{2M}{(2\pi)^{3/2}\sigma_x\sigma_y\sigma_z C_L}\right] \tag{3-3}$$

In this problem, the C_L will be either the lower flammability limit for flammable gases or the lower threshold value for toxic gases. Equation (3-3) gives the constant vapor concentration surface which is an ellipsoid with the center at $(x=Ut,\ y=0,\ z=0)$. When considering the effects at ground level, $z=0$ and the contour becomes an ellipse which is:

$$\frac{(x-Ut)^2}{\sigma_x^2} + \frac{y}{\sigma_y^2} = 2\,\ln\left[\frac{2M}{(2\pi)^{3/2}\sigma_x\sigma_y\sigma_z C_L}\right] \tag{3-4}$$

(b) Plume Model

The plume vapor concentration is given by:

$$C = \frac{2q}{(2\pi)U\sigma_y\sigma_z} \exp\left[-\frac{y^2}{2\sigma_y^2} - \frac{z^2}{2\sigma_z^2}\right] \tag{3-5}$$

where:

q = rate of vapor liberated (kg/s)

With a given concentration C_L, equation (3-5) becomes:

$$\frac{y^2}{\sigma_y^2} + \frac{z^2}{\sigma_z^2} = 2 \ln\left[\frac{2q}{2\pi U\sigma_y\sigma_z C_L}\right] \tag{3-6}$$

Since σ_y and σ_z are functions of x, the surface is like an elongated ellipsoid. On the ground $z = 0$, so we have:

$$y^2 = 2\sigma_y^2 \ln\left[\frac{2q}{2\pi U\sigma_y\sigma_z C_L}\right] \tag{3-7}$$

2. *Constant Toxic Casualty Contour, Outdoors*

In the VM the damage to personnel from toxicity, burn, and explosion is assessed by the probit equation which is defined as:

$$Pr = a + b \ln v \tag{3-8}$$

where v is the dosage, and the coefficients a and b are determined from existing experimental data. The variable Pr is referred to as a probit (probability unit). It is a Gaussian-distributed random variable with a mean value of 5 and a variance of 1. The percent of the vulnerable resources affected is the percent corresponding to the cumulative distribution of Pr. For a given probit Pr, the dosage is:

$$v = \exp\left(\frac{Pr - a}{b}\right) \tag{3-9}$$

The dosage v depends upon both the duration of exposure and the vapor concentration. The general form is:

$$v = \int_0^\infty C^n \, dt \tag{3-10}$$

where the exponent n is a real number.

(a) Puff Model

The toxic dosage for the puff model is obtained by substituting equation (3-2) into equation (3-10) and integrating over time. The resulting equation is:

$$v = \left(\frac{2M}{(2\pi)^{3/2}\sigma_x\sigma_y\sigma_z}\right)^n \left(\frac{\pi}{2n}\right)^{1/2} \frac{\sigma_x}{U} \left[1 + erf\left(\sqrt{\frac{n}{2}}\ \frac{x}{\sigma_x}\right)\right] \exp\left[-\frac{n}{2}\left(\frac{y^2}{\sigma_y^2} + \frac{z^2}{\sigma_z^2}\right)\right] \tag{3-11}$$

where *erf* is the error function. For a given v and $z = 0$, we have:

$$y^2 = \frac{2\sigma_y^2}{n}\ \ell n \left\{\left(\frac{2M}{(2\pi)^{3/2}\sigma_x\sigma_y\sigma_z}\right)^n \left(\frac{\pi}{2n}\right)^{1/2} \frac{\sigma_x}{vU}\left[1 + erf\left(\sqrt{\frac{n}{2}}\ \frac{x}{\sigma_x}\right)\right]\right\} \tag{3-12}$$

The dispersion coefficients ($\sigma_x, \sigma_y, \sigma_z$) increase monotonically with x so that at a certain distance the argument of the logarithm will be unity or y will approach zero. So the contour is a closed curve. Five curves corresponding to 1%, 25%, 50%, 75% and 99% casualties are calculated. The probits corresponding to these percentages are 2.67, 4.33, 5.0, 5.67 and 8.09.

(b) Plume Model

The dose equation for the plume model is:

$$v = \left(\frac{2q}{2\pi U\sigma_y\sigma_z}\right)^n t_e \exp\left[-\frac{n}{2}\left(\frac{y^2}{\sigma_y^2} + \frac{z^2}{\sigma_z^2}\right)\right] \tag{3-13}$$

where t_e is the total evaporation time. In the same manner as in (a) above, for $z = 0$ we have:

$$y^2 = \frac{2\sigma_y^2}{n}\ \ell n\left[\frac{t_e}{v}\left(\frac{2q}{2\pi U\sigma_y\sigma_z}\right)^n\right] \tag{3-14}$$

Also, five curves of percent of casualties are calculated as in (a) above.

3. *Thermal Damage from Flash Fire Model*

The general dose equation for thermal damage is:

$$v = \int I^n \, dt \qquad (3\text{-}15)$$

where I is the radiation intensity (J/m^2-s) and n is a real number. The flash fire model is divided into two phases: burning phase and cooling phase. The burning phase starts from the ignition and stops when the fuel is burned out. The cooling phase is the period when the hot vapor cools down to ambient or near-ambient temperature. For personnel damage, only radiation from the burning phase is considered [5].

The thermal dosage for flash fire in the burning phase is given by:

$$V = \frac{3}{11} \, \frac{1}{S} \left(\alpha \varepsilon \sigma T_f^4 \right)^{4/3} \left(\frac{r_b}{d} \right)^{8/3} r_b \qquad (3\text{-}16)$$

where:

S = flame velocity (m/s)

T_f = flame temperature (°K)

r_b = fireball radius (m)

d = distance from the fire center (m)

α = absorptivity

ε = emissivity

σ = Stefan-Boltzmann constant (J/m^2-s-$°K^4$)

The fireball radius is equal to:

$$r_b = \left(\frac{3 M_0 T_f}{4 \pi \rho_{p0} T_0} \right)^{1/3} \qquad (3\text{-}17)$$

where:

M_0 = vapor mass burned (kg)

ρ_{p0} = density of products at ambient temperature (kg/m^3)

T_0 = ambient temperature (°K)

Equation (3-16) can also be written as:

$$d = \left(\frac{3}{11}\ \frac{1}{vS}\right)^{3/8} \left(\alpha\varepsilon\sigma T_f^4\right)^{1/2} r_b^{11/8} \qquad (3\text{-}18)$$

When the dosage v is given, the corresponding distance from the fire center d is determined.

4. *Damage from Explosion*

Explosion casualty is caused by either the peak overpressure or the impulse from the explosion.* The dosage v in the probit equation is, therefore, the overpressure $P(\mathrm{N/m^2})$ or the impulse I $(\mathrm{N\text{-}s/m^2})$.

The energy yield in a gas explosion is described by the following equation:

$$W = (-\Delta H)\ \frac{M_e}{M} \qquad (\mathrm{Kcal}) \qquad (3\text{-}19)$$

where:

ΔH = heat of combustion (Kcal/kg-mol)

M_e = mass of exploding fuel (kg)

M = molecular weight of the fuel

The damage assessment due to explosion is caculated from the scaling laws which are stated as follows:

$$d_s = \frac{d_a\ (P/P_0)^{1/3}}{(W'/W_0)^{1/3}\ (T/T_0)^{1/3}} \qquad (3\text{-}20a)$$

$$t_a = \frac{t_s\ (W'/W_0)^{1/3}}{(P/P_0)^{1/3}\ (T/T_0)^{1/6}} \qquad (3\text{-}20b)$$

$$I_a = \frac{I_s\ (W'/W_0)^{1/3}\ (P/P_0)^{2/3}}{(T/T_0)^{1/6}} \qquad (3\text{-}20c)$$

where:

d_s = scaled distance from explosion center (m)

d_a = actual distance from explosion center (m)

P,T = pressure and temperature of the atmosphere in the actual case (bar, °K)

---

*Only overpressure effects are currently being depicted in the graphical displays for explosion damage.

P_0, T_0 = pressure and temperature of the atmosphere in the case of the reference explosion (P_0 = 1 bar, T_0 = 288.15°K)

W' = effective energy yield of the actual explosion

W_0 = energy yield of the reference explosion (1 kg of TNT yields 1.12×10^6 calories; thus, $W_0 = 1.12 \times 10^6$ calories)

t_a = actual time (s)

t_s = scaled time (s)

I_a = actual impulse (N-s/m^2)

I_s = scaled impulse (N-s/m^2)

These laws are simplified considerably if the actual explosion is assumed to occur in the same atmosphere as the reference explosion. Since ratios of absolute values for atmospheric pressure and temperature are raised to fractional powers, these factors are close to unity even when the reference and actual atmospheres are not identical. By assuming essentially identical atmospheres, one obtains:

$$d_s = \frac{d_a}{(W'/W_0)^{1/3}} \quad (3\text{-}21a)$$

$$t_a = t_s \; (W'/W_0)^{1/3} \quad (3\text{-}21b)$$

$$I_a = I_s \; (W'/W_0)^{1/3} \quad (3\text{-}21c)$$

For an explosion with a center on a rigid surface, the surface reflects completely all explosive energy impinging upon it. If the ground can be considered as a rigid surface, then the effective energy yield will be twice the explosive energy yield, or:

$$W' = 2W \quad (3\text{-}22)$$

The data for a reference spherically symmetrical explosion are stored in the computer. If the critical impulse for body injury is determined, the critical distance for a certain explosive mass can be obtained from equations (3-20a) or (3-21a) and the reference data. The procedure is as follows:

1. Compute W and W' from equations (3-19) and (3-22).
2. Compute dose v for a given probit from equation (3-8) for impulse.
3. Let $I_a = v$ and compute I_s from equations (3-20c) or (3-21c).

4. From the reference data, find the scaled distance d_s corresponding to the I_s.
5. Compute actual distance d_a which is the radius of the constant casualty curve.

C. *MODIFICATION OF VM AND ADDITION OF NEW SUBROUTINES*

The VM has been modified and several new subroutines have been added. A control variable has been installed by which the user can direct the program to generate the plotting data. The new subroutines are:

PLOTIN: Based on the physical properties of the vapor, this subroutine calls various subroutines to generate the plotting data.

PUFPLO: This subroutine generates the coordinates for the lower threshold value curve or the lower flammability curve for the puff model.

PLMPLO: This subroutine generates the coordinates for the lower threshold value curve or the lower flammability curve for the plume model.

FLASPL: This subroutine calculates the coordinates for the constant lethality curve and nonlethal curve from a flash fire burn. Five curves for each case are generated, corresponding to 1, 25, 50, 75 and 99 percent casualties.

TOXPLO: This subroutine calculates the coordinates of constant casualty curves from toxic gas for both puff and plume models. Five curves for each case are generated, i.e., 1, 25, 50, 75 and 99 percent casualties.

EXPPLO: This subroutine generates the coordinates of constant casualty curves from explosion including peak overpressure, impulse, and flying fragments. It also generates the constant damage curves for structures.

Each of the subroutines which produce the damage extent data bases for eventual conversion to visual displays is keyed on a three- or five-tiered probit analysis scheme, in which three (1%, 50% and 99%) or five (1%, 25%, 50%, 75% and 99%) curves corresponding to distance at which each percent of damage is likely to occur are computed to form the curve family.

The data bases per curve family are coded using a general format which enables subsequent reading of the data in a simple manner. The "write" format is in the following order:

NPLOT,I,J,X(J),Y1(J),Z

where:

NPLOT is an integer value (I3) corresponding to a plot file code for subsequent sorting and identification by the display programs.

I is the number of the current set of data corresponding to either a certain elapsed time or distance, incremented by a constant amount

J is the number of the current set of data corresponding to I and to a particular probit level

X(J),Y1(J) is the ordered set of coordinates computed to correspond to I and J, converted to units of meters

Z is the alphanumeric name of the cell corresponding to I.

There are certain exceptions to the variable types written in this format. The entire set of cells from the coordinate-transformed Geographical file is written onto the Output file (TAPE36) as X(J) and Y1(J), with NPLOT=1, and J not used—instead, I is used as the increment index. In PLOTIN, NPLOT=199 and the values of the flammability and toxicity flags are stored in I and J, respectively, with the values of the total mass of gas (sum of data in field numbers 4001 and 4023) and exploded mass, if any, stored in X and Y1. In VMEXEC, NPLOT=200 and the values of the wind speed and either lower flammability limit (g/cm^3) or irritation threshold (g/cm^3) are stored in X and Y1, respectively.

In subroutines FLASPL and EXPPLO, the number of the probit curve is stored in I, the number of the cell in which ignition occurs goes in J, and the radius corresponding to I is placed in X, with Y1 getting the value of the percentage corresponding to I and Z left unwritten (as also is the case in all other TAPE36 writing sections, except for the one transferring the values of the transformed cell coordinates).

PUFPLO sets NPLOT=2 for the puff irritation (toxic submodel) curve family and NPLOT=3 for the puff lower flammability limit family.

PLMPLO sets NPLOT=4 for the plume irritation curve family and NPLOT=5 for the plume lower flammability limit family.

FLASPL sets NPLOT=6 for the curve family corresponding to flash fire death (lethality) and NPLOT=7 for the family corresponding to flash fire first-degree burn (injury), regardless of whether the plume or puff model is used.

TOXPLO sets NPLOT=10 for the toxic death curve family and NPLOT=11 for the toxic injury family if the plume model is used, or NPLOT-12 for toxic death curves and NPLOT=13 for toxic injury curves if the puff model is used.

EXPPLO sets NPLOT=17 for the death from overpressure curve family, NPLOT=18 for the injury from overpressure family, and NPLOT=19 for the structural damage family, again regardless of dispersion model type.

All of the subroutines which perform calculations for the plot file data base contain zero-divide safeguard coding. The user is cautioned that if errors occur in the execution of earlier subroutines they will be passed into the display subroutine sections (if a "fatal" error does not prevent this) since no range checks on the incoming data are performed.

Besides the additional subroutines for the VM, four independent programs have been created for plotting.

DISFTN: This is a procedure file which controls the use of DISSPLA, a plotting software package, under NOS. The procedure file takes a source file, compiles it, links with the DISSPLA library, and executes it. DISFTN also retrieves a Tektronix terminal status definition file, TEKANS (for Model 4010-4012 configurations only).

The following are the three source files:

TOXDISP: This program requests and reads the plotting data file name and attaches the file to the user's workspace as a secondary file. It next requests and reads a user-supplied 20-character or less plot title, for identification purposes, to which it adds its own title. It also reads the cell number of new spill location (if any) and the new wind direction with the x-axis (if any). Then the program reads the toxic data from the attached file, rearranges the data if necessary, and determines the scale of the graphs. It plots the lower threshold value curves, constant lethality curves and constant nonlethality curves (if any) for the puff or plume model.

FIRDISP: This program is similar to TOXDISP except that it plots the lower flammability limit curves, constant lethality curves and nonlethality curves from the flash fire or fireball model.

EXPDISP: This program is also similar to TOXDISP, but it will not read the new wind direction because the explosion effect is one of spherical symmetry. It plots the constant lethality and nonlethality casualty curves from explosion and the constant structural damage curves due to overpressure.

Appendix D contains a listing of the above programs and DISFTN.

Only one additional user input variable for the VM is needed and that is the plotting control variable, KPLOT:

Field Number	Default Value	Unit	Variable Name	Comment
4014	0	none	KPLOT.	=0, no plotting data generated; =1.0, generates plotting data

Execution of the VM with a request for plot file generation normally results in an increase in system resources demand of approximately 75% to 100% beyond a non-plot file generation run using otherwise identical input files. A successful execution of the former type results in TAPE36, the plot data base file, routed to the NOS disk file via station KEB immediately after PHASE1 is executed, just prior to the loading of PHASE2. TAPE36 is transmitted as a direct-access (ATTACH-type) file, since it will normally be quite lengthy, and is renamed using the system-declared name for the particular job (e.g., AVAKCSP), and must be called for under this name, not as TAPE36. A scan of the dayfile attached to the run or of the current NOS disk catalog will produce the name of the routed file.

A special Cycle-15 VM jobstream named DISPVM has been written and stored in the S7205 disk catalog for easy usage of the KEB routing facility. The jobstream is presented in Figure 3-1 and is submitted after calling in the appropriate Geographical file to the workspace and renaming it GEOG, as well as naming the Input file VMINPUT, using this command:

SUBMIT,DISPVM,ST=stationid,T.

D. *USAGE OF THE DISPLAYS*

The user can run the VM by remote job entry from NOS by using either UIM version alone (not file -RUIM) or by creating the input file manually. The time-sharing user can submit the job by entering the SUBMIT command. The format is:

SUBMIT,job file name,ST=id,T.

where id is a three-character site identifier that specifies what SCOPE 3.4 site should receive the transmitted file (for the Eastern CYBERNET Center at Rockville, Maryland, the id is ECZ). After the job has entered into the local batch queue, the system responds:

hh,mm,ss,jobname

where hh,mm,ss, is the time that the job entered the batch queue (hours, minutes, seconds). The jobname will also be the name of the generated plotting data file which is routed back to NOS. The user is advised to write this name down for reference. The following is an example:

```
/SUBMIT,DISPVM,ST=ECZ,T.
 10.08.12.AVDOAYO
/
```

The first line is typed by the user and the second line is printed by the terminal. DISPVM is the job file and AVDOAYO is the system-declared jobname and also will be the name of the generated plotting data file, which will appear in the NOS disk catalog as a direct access file.

In the Geographical file, the cells are identified by the ID numbers which are usually the same as the census tract codes. When the VM reads the file, it rearranges the cells into sequential numbers (1,2,3...) and calculates the transformed coordinates (x and y) for each cell using the spill location as origin. In the printout of the VM job, the user finds

```
READY.
LIST

 79/06/11. 17.05.27.
PROGRAM   DISPVM

/JOB
DISPLVM,NT1,CM310000,T100,P3.
USER [redacted]
PROJECT,*MRT*ECI.
REWIND(OUTPUT)
ROUTE,OUTPUT,UN=C,TID=UN,DC=PR,DEF.
HEADING.X1PLS HOLD
HEADING.X U S C G
HEADING.X1 VUL. MOD.
HEADING.X   OUTPUT
HEADING,,1.  PLOTFILE
COPYBR,,TAPE15.
REWIND,TAPE15.
REQUEST,CHEMTAP,NT,PE,NORING,CT=PU,ID=USCG,VSN=0S7072.
COPYBF,CHEMTAP,TAPE9.
COPYBF,CHEMTAP,TAPE10.
COPYBF,CHEMTAP,TAPE14.
REWIND(CHEMTAP,TAPE9,TAPE10,TAPE14)
RETURN,CHEMTAP.
ATTACH,VM,USCGVULMODLGO,CY=15,ID=USCG.
COPYBF,VM,PH1BIN.
COPYBF,VM,PH2BIN.
LDSET(PRESET=ZERO)
MAP,PART.
PH1BIN.
REWIND(TAPE36)
ROUTE(TAPE36,DC=FL,ST=KEB)
REWIND(TAPE12,TAPE13,TAPE14)
PH2BIN.
/EOR
/NOSEQ
/PACK
/READ,GEOG
/EOR
/READ,VMINPUT
/EOR
/EOF
READY.
```

FIGURE 3-1

VM Display Plot File Routing Jobstream: DISPVM

a table called Geographical Data which lists the sequential number, cell ID, latitude, longitude, x-coordinate, and y-coordinate of each cell. The reason we describe this process in detail is that in the display, the cells' locations are represented by the centers and marked with the *sequential* number. With the Geographical Data table and the census map, the user can then find the area covered by the vapor clouds.

The following example illustrates the steps for producing display output. In the example, it is assumed that: (1) the user wants to display toxic casualties, so the program TOXDISP is used; (2) the plotting data file is AVDOAYO; (3) the user wants to change the spill location to cell 35; and (4) the user wants to change the wind direction to -15 degrees from the old wind direction. In the example, the letter "U" (USER) means that the user types in the data or answer, the letter "T" (TERMINAL) means that the terminal prints the message, and (cr) means to depress the return key.

1. Sign on the system

2. U: OLD,TOXDISP (cr)
   T: READY.

3. U: -DISFTN(F=TOXDISP) (cr)

4. T: WHAT IS THE PLOTTING FILE NAME:
   U: AVDOAYO (cr)

5. T: ENTER THE PLOT TITLE (<21 CHARS.)--
   U: CLX SPILL /RUN 25 (cr)

6. T: DO YOU WANT TO CHANGE THE SPILL LOCATION?
   ANSWER 1 FOR YES, 0 FOR NO
   U: 1 (cr)

7. T: WRITE THE CELL NUMBER WHERE THE SPILL WILL OCCUR
   U: 35 (cr)

8. T: DO YOU WANT TO CHANGE THE WIND DIRECTION FROM THE ONE
   WHICH YOU USED TO CALCULATE THE PLOTTING DATA?
   ANSWER 1 FOR YES, 0 FOR NO
   U: 1 (cr)

9. T: WRITE THE WIND DIRECTION IN DEGREES: COUNTERCLOCKWISE
   IS POSITIVE; CLOCKWISE IS NEGATIVE
   U: -15.0 (cr)

With these data entries, the computer starts to execute and display automatically. A typical 3-frame run requires about 10-20 minutes of time at 300 BAUD (about 4-10 minutes at 1200 BAUD) and generally "costs" about 80 SBU's.

The user may obtain hard copies of the displays by (1) Polaroid photography of the finished frame on the CRT terminal (each frame generally is held for about 20 seconds by the computer before erasure) or by (2) saving the display program-created intermediate plotting data file, named NPFILE, and processing it for a CALCOMP batch job to produce India-ink-on-paper reproductions of the image frames. For purpose (2), a special submission jobstream, CALPLOT, has been created and is described next.

If the user is satisfied with the plot frames, immediately after the system returns control of the CRT terminal to him, he should proceed to reprocess the intermediate, temporary plotting file named NPFILE (for "Neutral-Picture FILE") into a CALCOMP-compatible data file named PLOTF. This is done using the following commands:

```
U:  NULL    (cr)
T:  READY.

U:  REWIND,NPFILE    (cr)
T:  READY.

U:  CALL(UNIPROC,S=2POST(DEVI=ROCKVIL)    (cr)
T:  (after a short delay)
    1 UNIPOST V2.1 INPUT DIRECTIVES

    ?
U:  $    (cr)
```

The computer will then take a few seconds to process the NPFILE and will return with:

```
T:  READY.

U:  GET,CALPLOT    (cr)
T:  READY.

U:  SUBMIT,CALPLOT,ST=stationid,T    (cr)
T:  hh,mm,ss,jobname
```

The listing of CALPLOT and its associated information file, PLTINFO, is presented in Appendix B.

To pick up the CALCOMP plots, the user needs to have placed his phone number and name in PLTINFO so that the local CDC cluster center can notify him when they are ready for pickup (generally, allow one full day).

Example CALCOMP plots are presented as Figures 3-2 through 3-21 on the following pages and illustrate the outputs from the various display programs.

E. *FLOW DIAGRAMS*

Figures 3-22 through 3-30 (pp. 3-36 through 3-48) depict the revised and appended flowcharts illustrating the changes made in incorporating the display plot file producing code. Figure 3-30 shows the flowchart for program TOXDISP; since FIRDISP and EXPDISP are similarly configured, they are not shown.

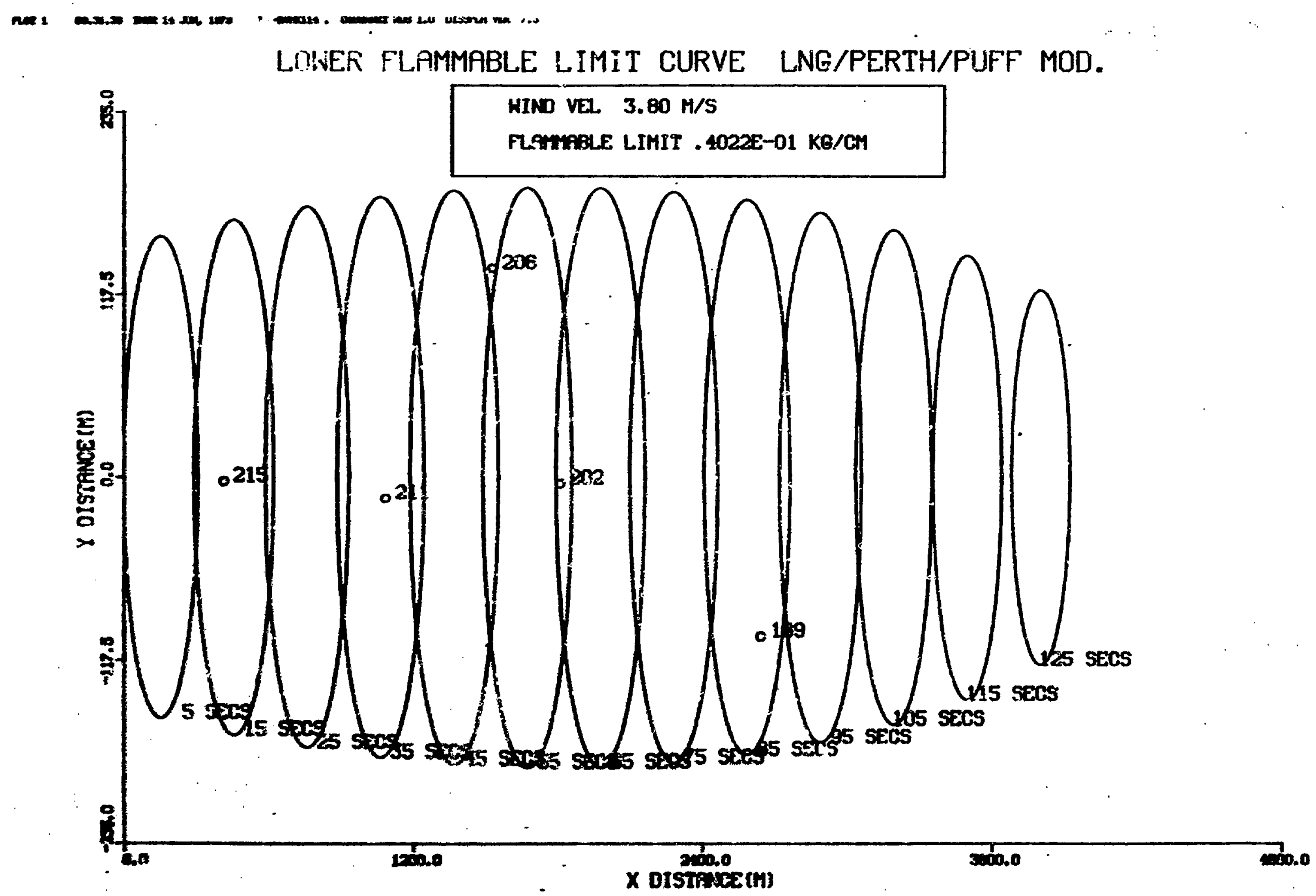


FIGURE 3-2. Lower Flammable Limit Curve: LNG/Perth Amboy/Puff Model

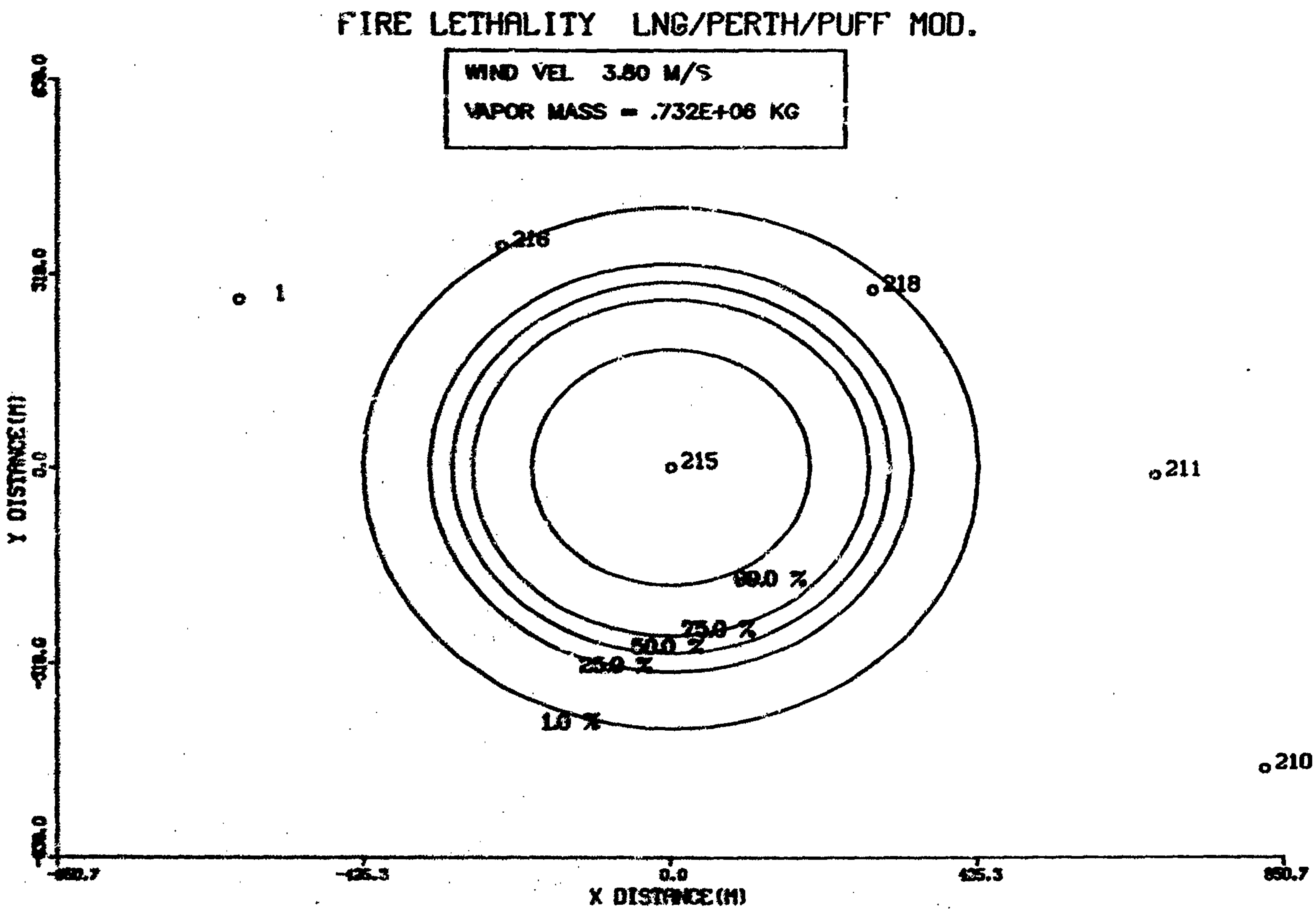


FIGURE 3-3. Fire Lethality: LNG/Perth Amboy/Puff Model

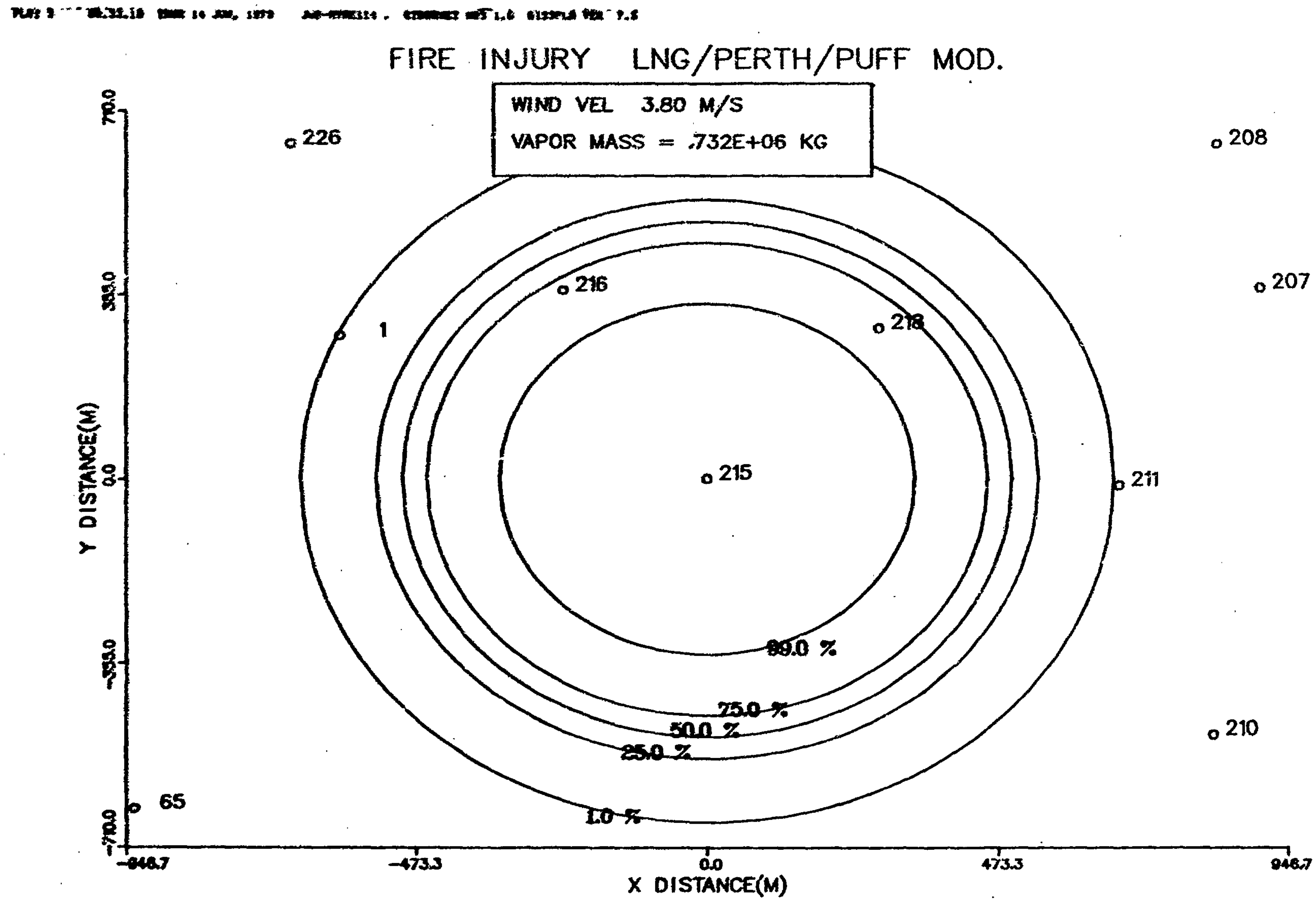


FIGURE 3-4. Fire Injury: LNG/Perth Amboy/Puff Model

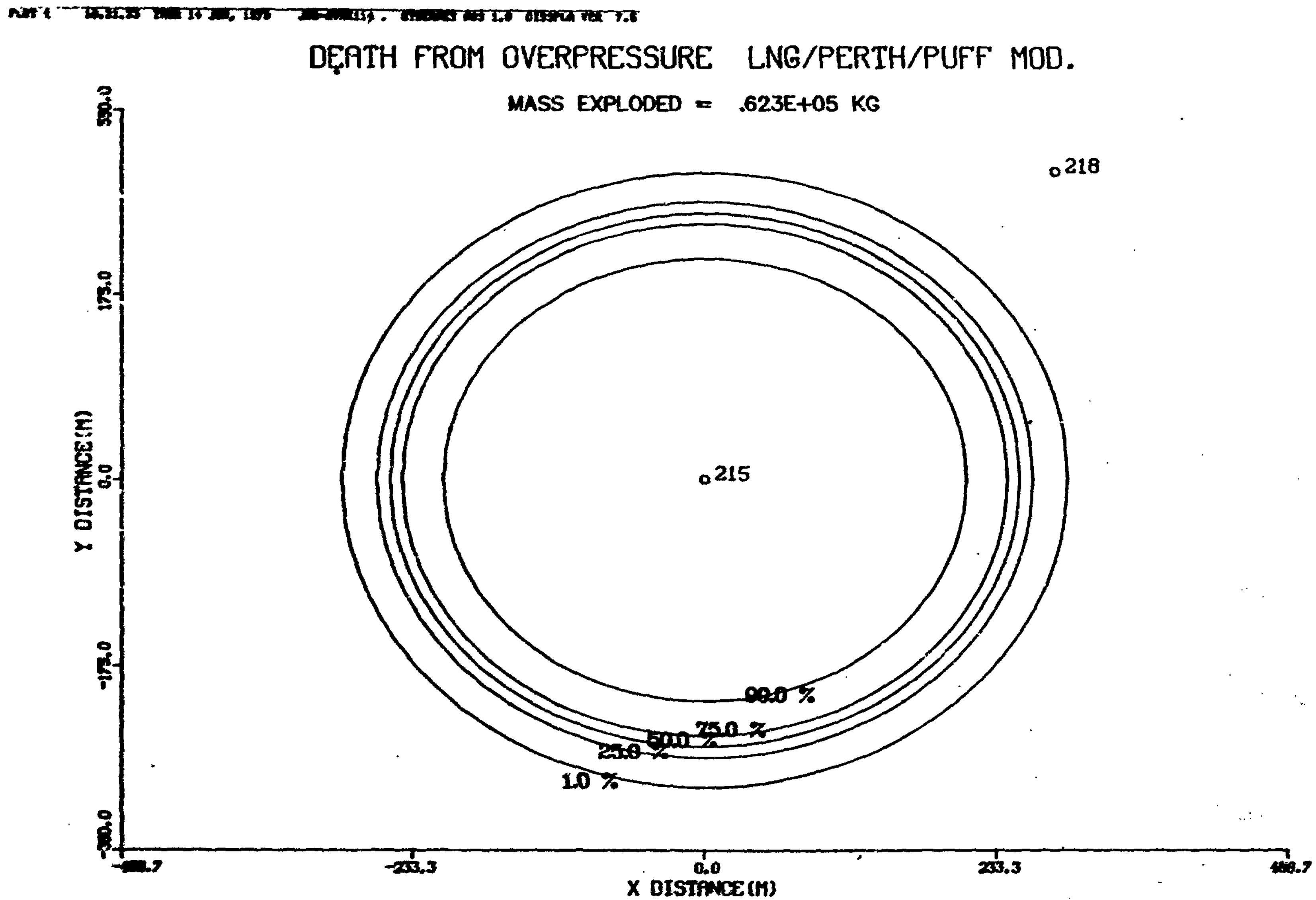


FIGURE 3-5. Death from Overpressure: LNG/Perth Amboy/Puff Model

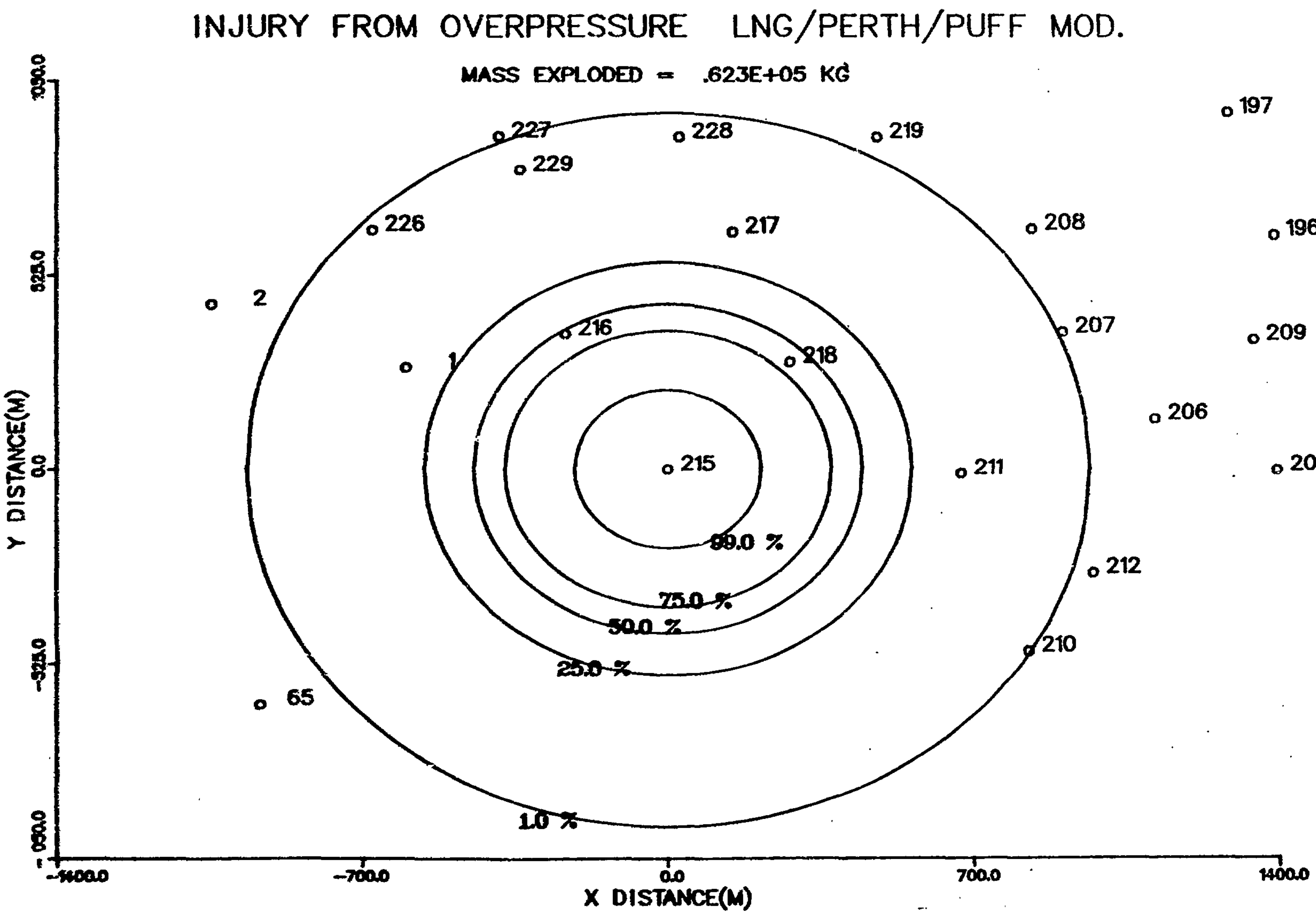


FIGURE 3-6. Injury from Overpressure: LNG/Perth Amboy/Puff Model

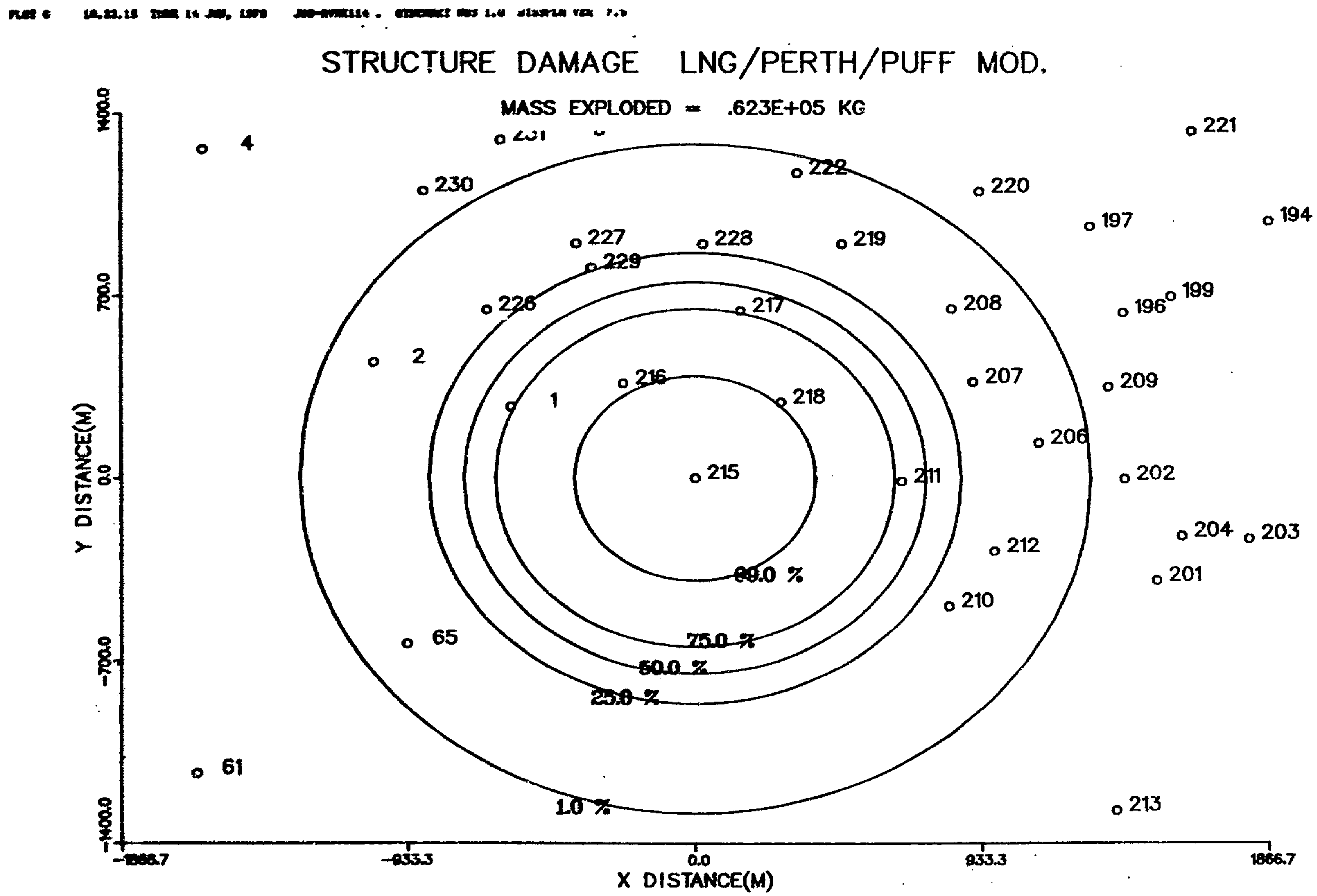


FIGURE 3-7. Structure Damage: LNG/Perth Amboy/Puff Model

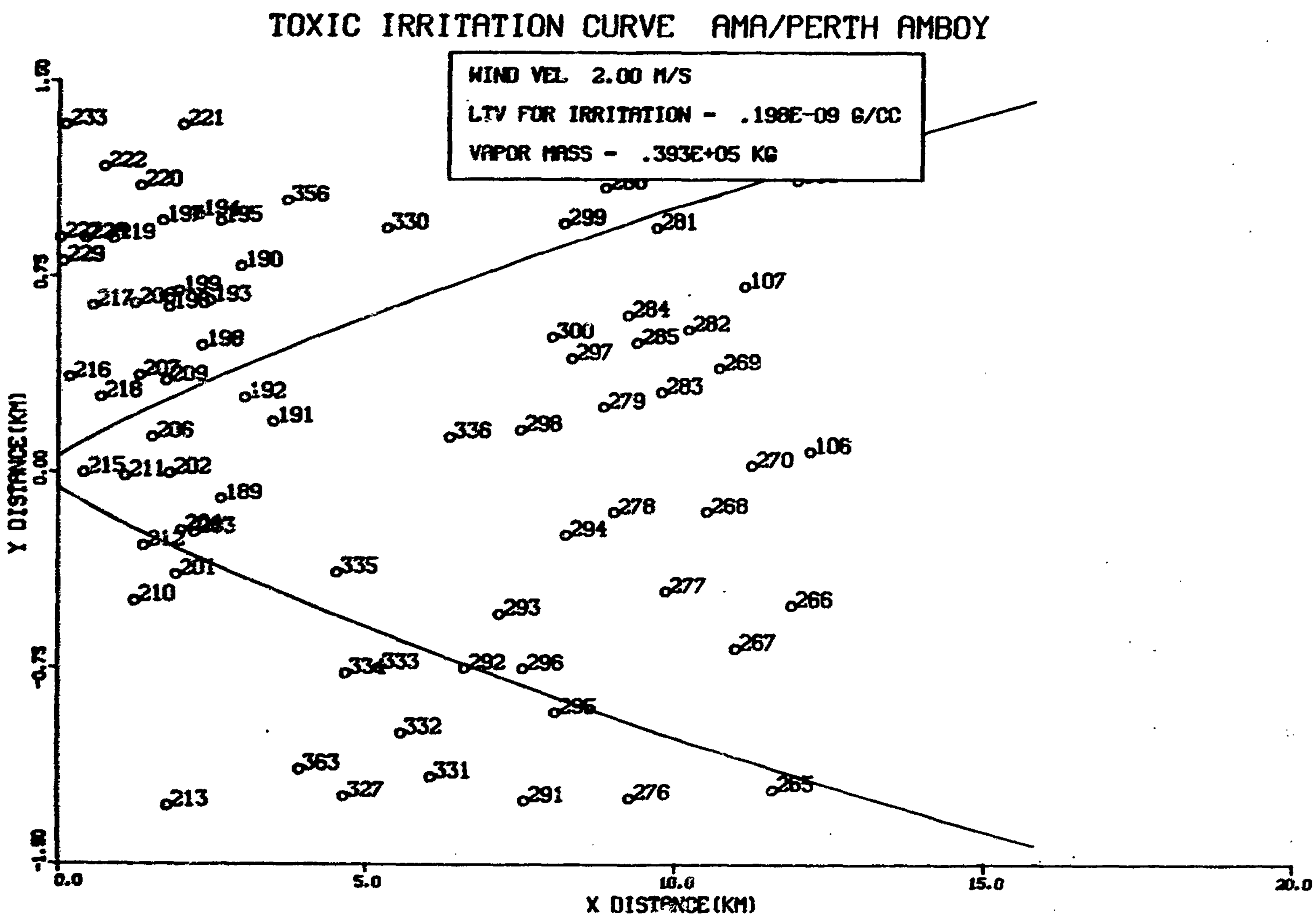


FIGURE 3-8. Toxic Irritation Curve: AMA/Perth Amboy

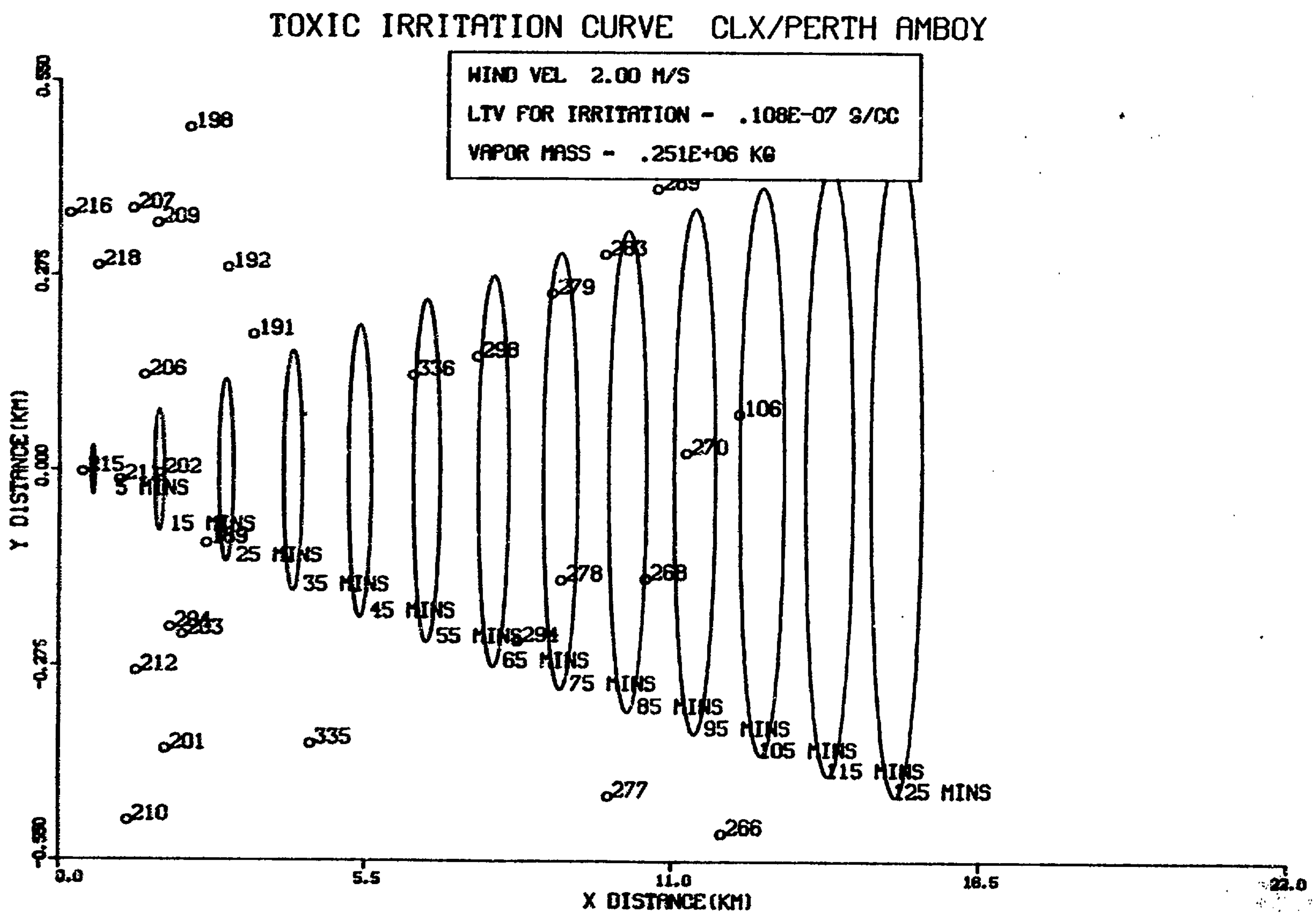


FIGURE 3-9. Toxic Irritation Curve: CLX/Perth Amboy

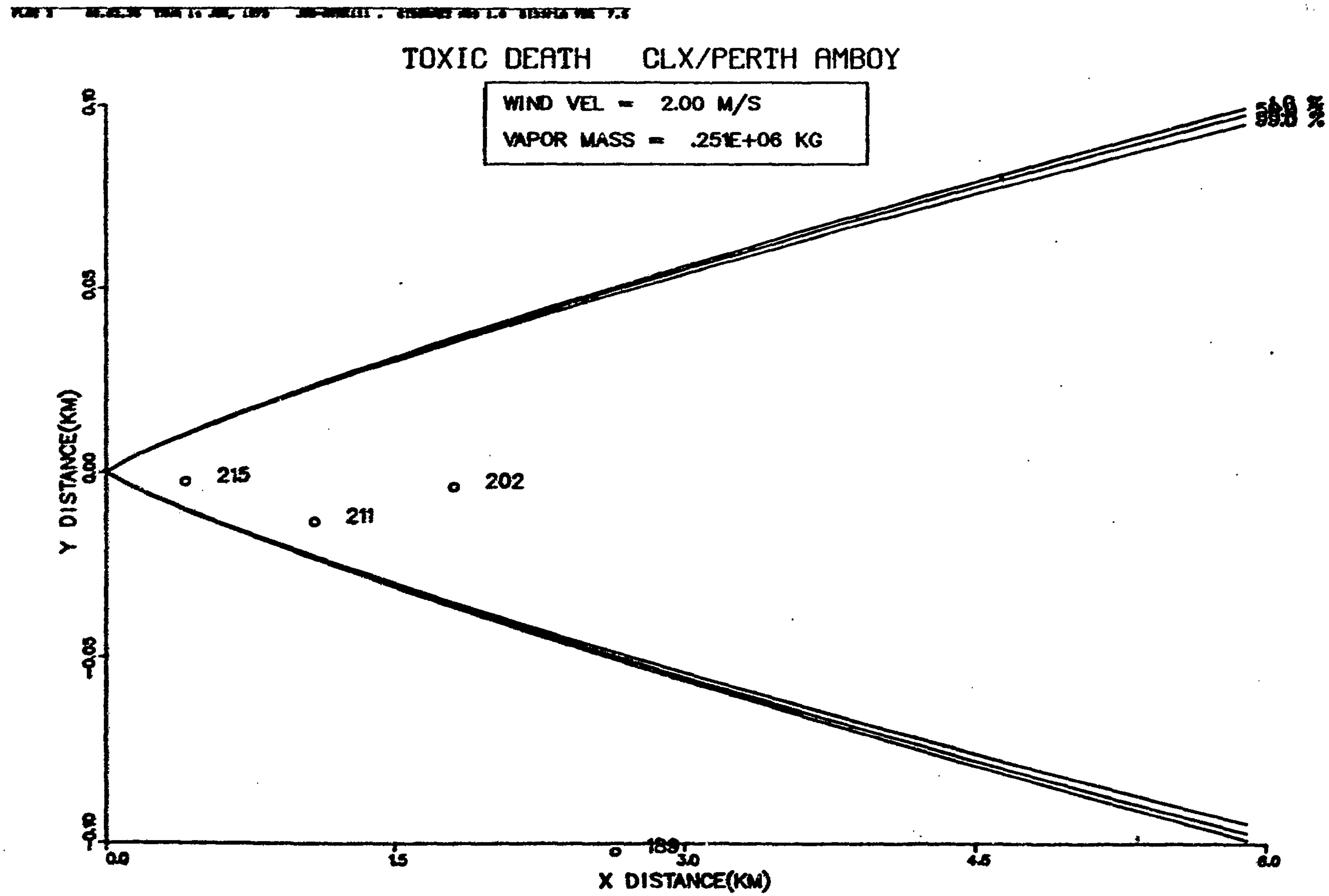


FIGURE 3-10. Toxic Death: CLX/Perth Amboy

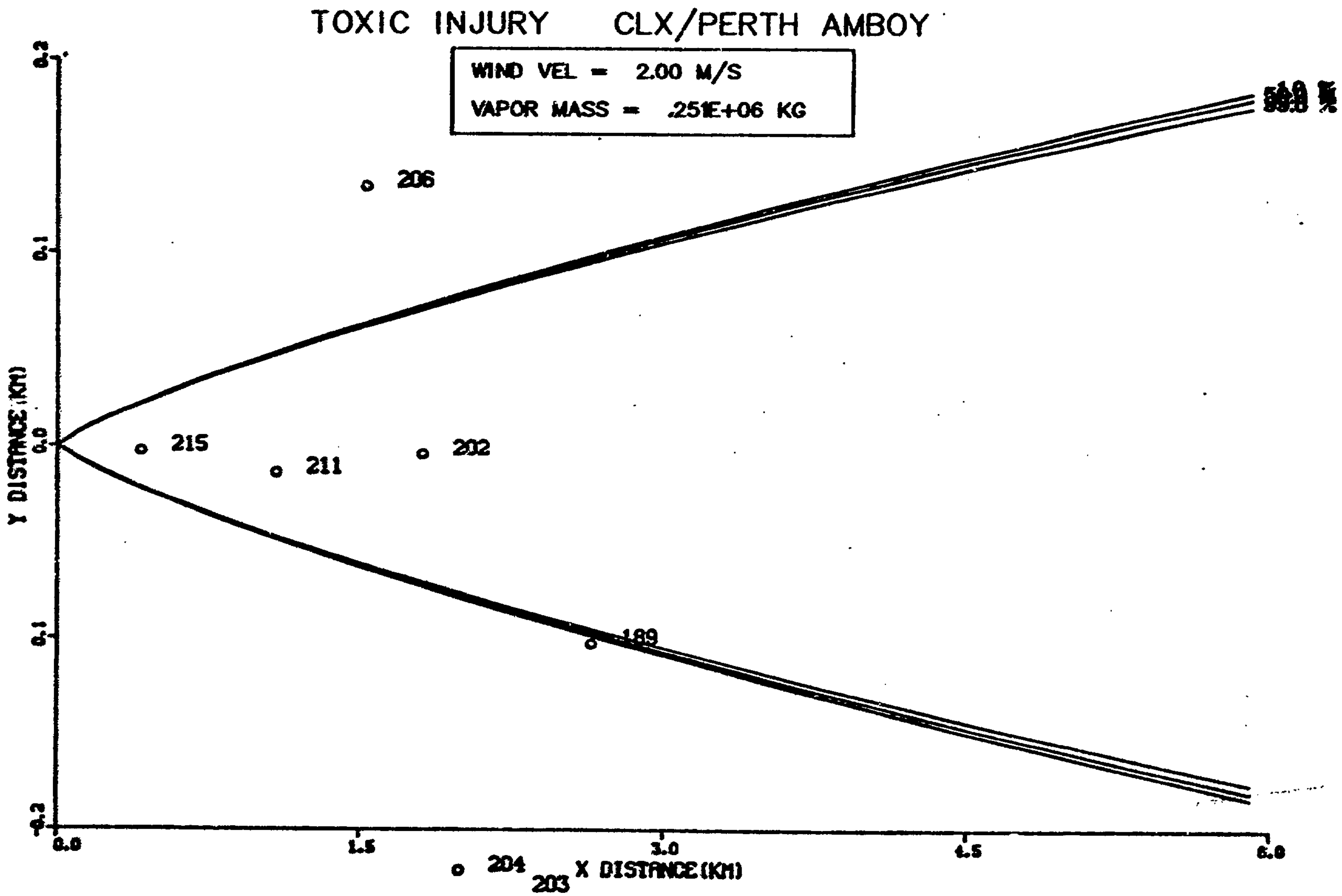


FIGURE 3-11. Toxic Injury: CLX/Perth Amboy

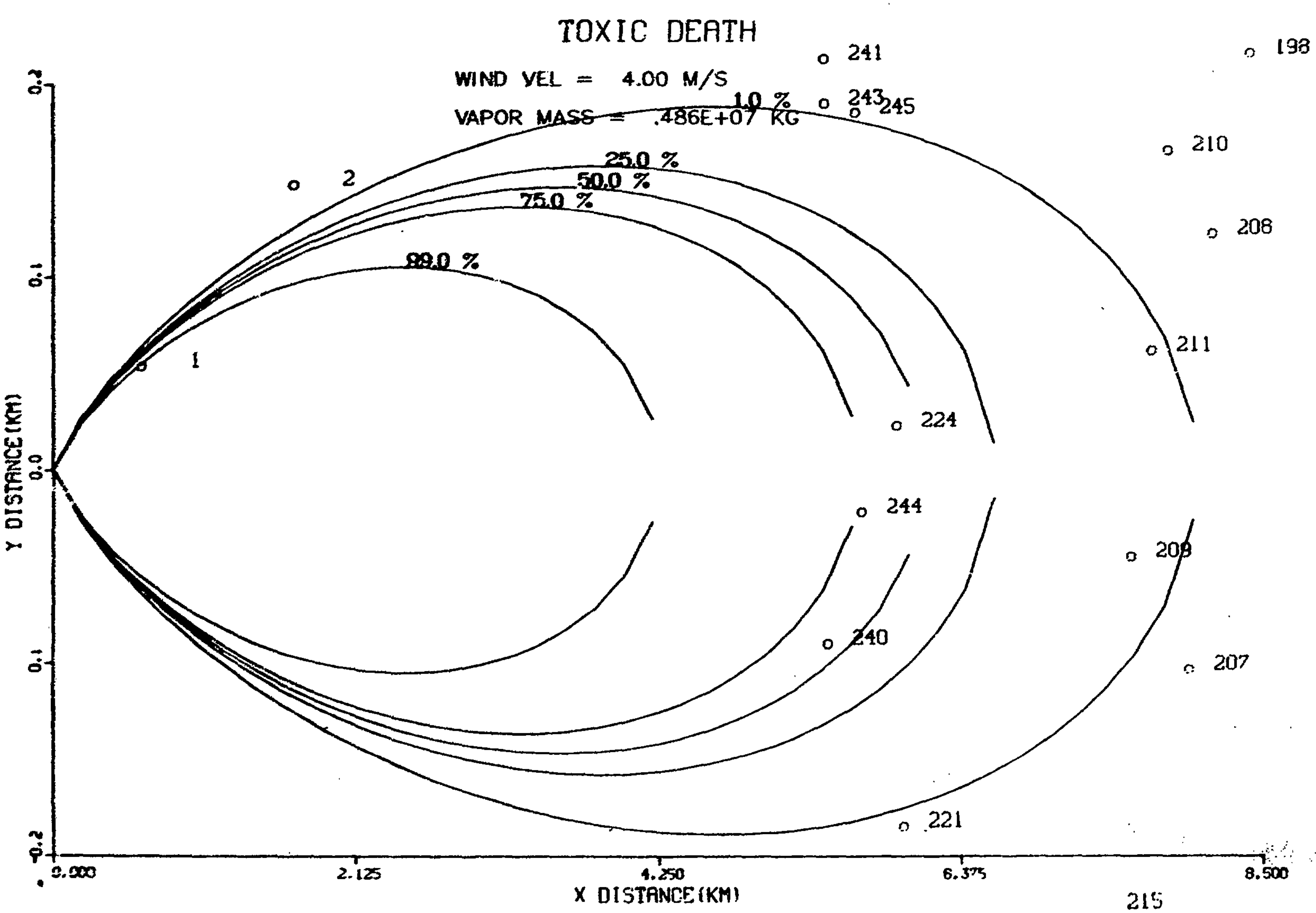


FIGURE 3-12. Toxic Death: Methyl Bromide

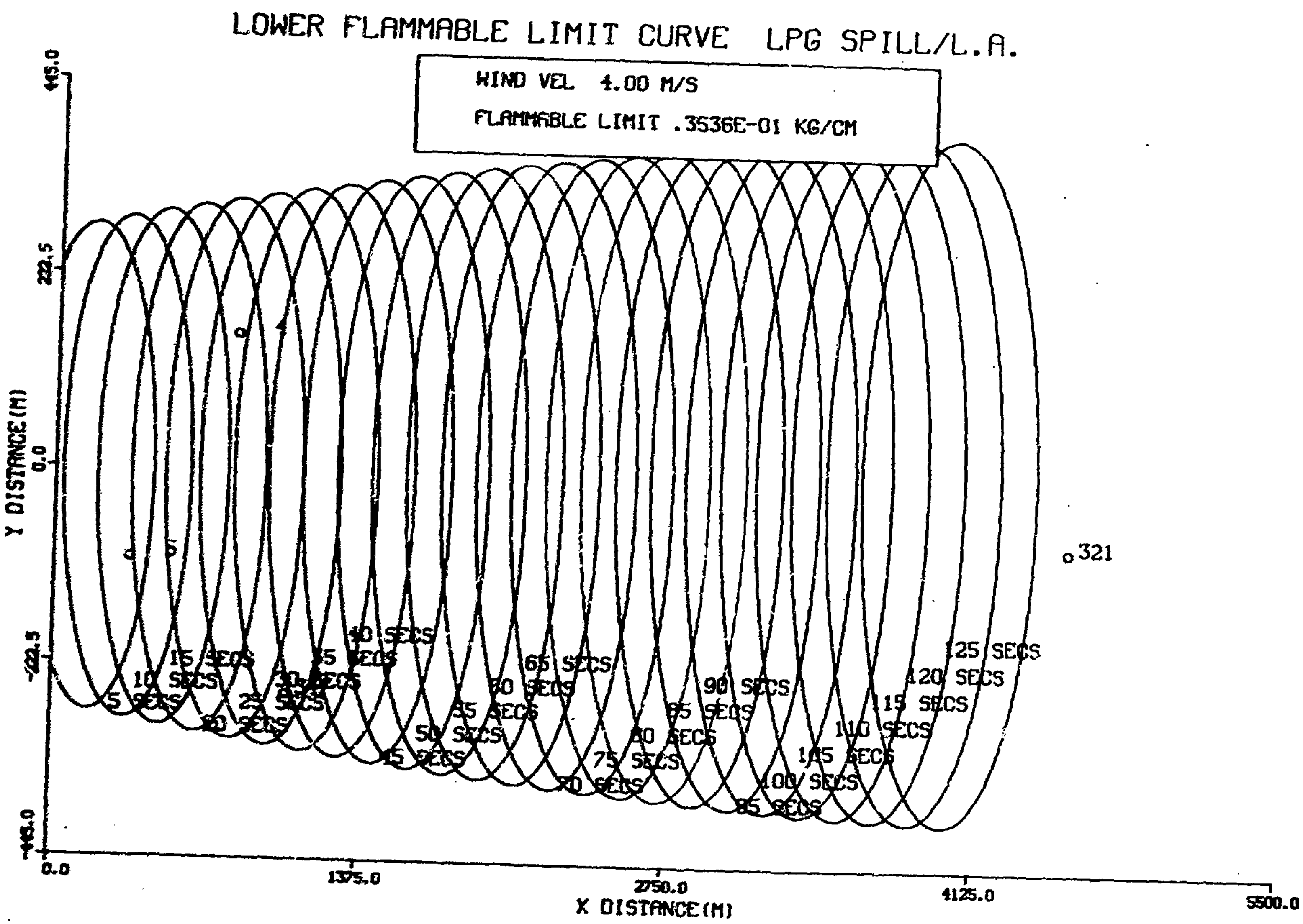


FIGURE 3-13. Lower Flammable Limit Curve: LPG Spill/Los Angeles

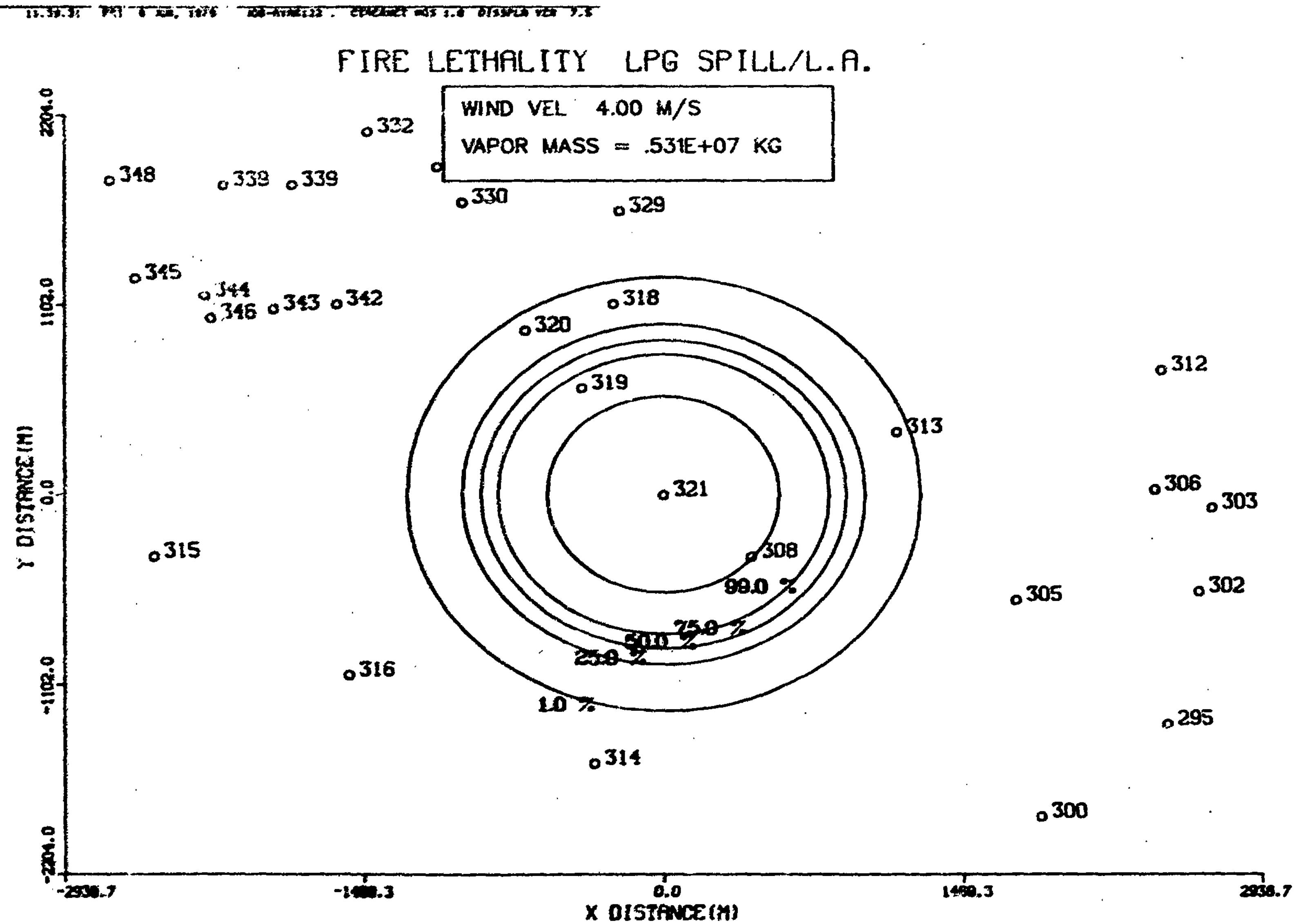


FIGURE 3-14. Fire Lethality: LPG Spill/Los Angeles

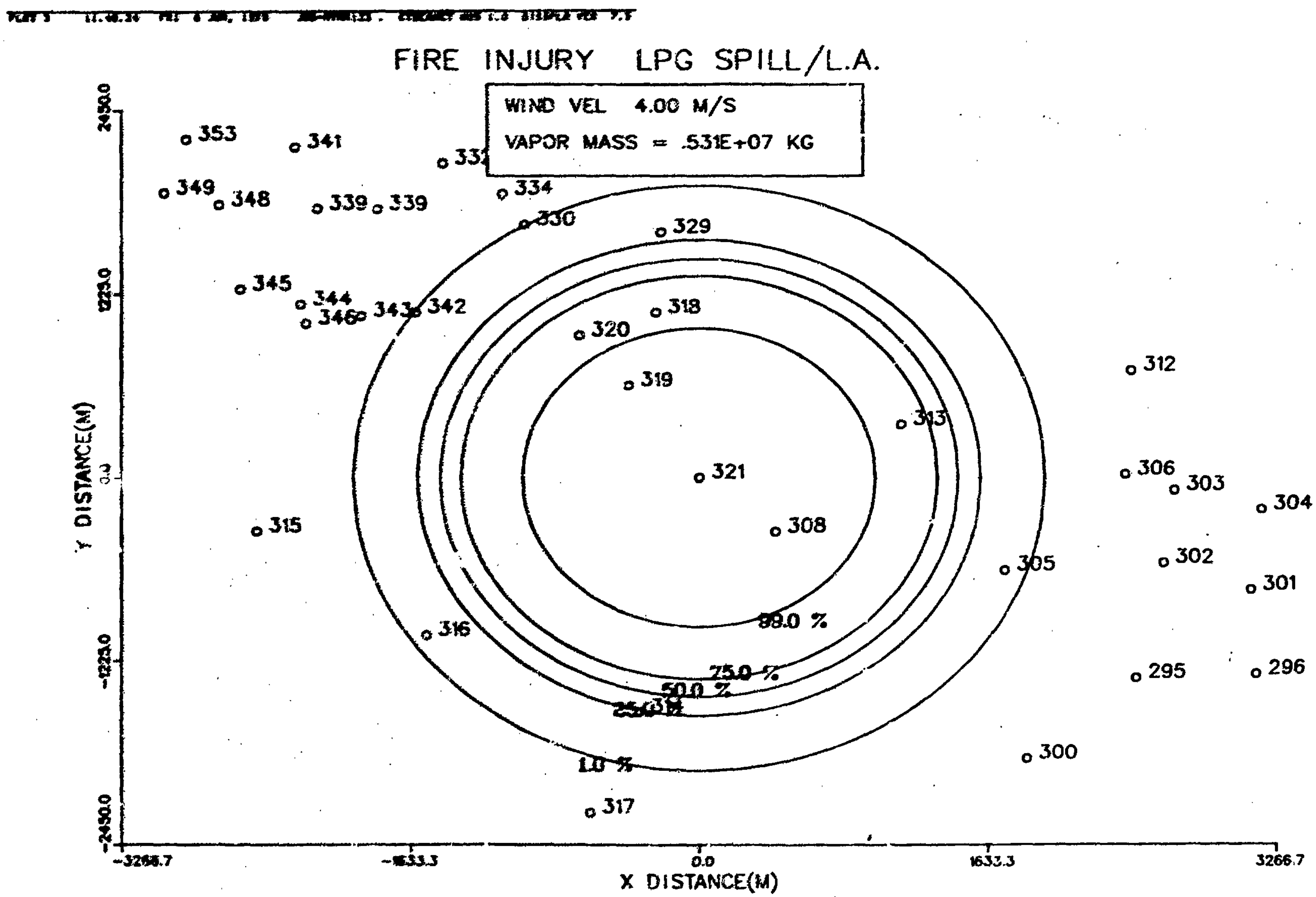


FIGURE 3-15. Fire Injury: LPG Spill/Los Angeles

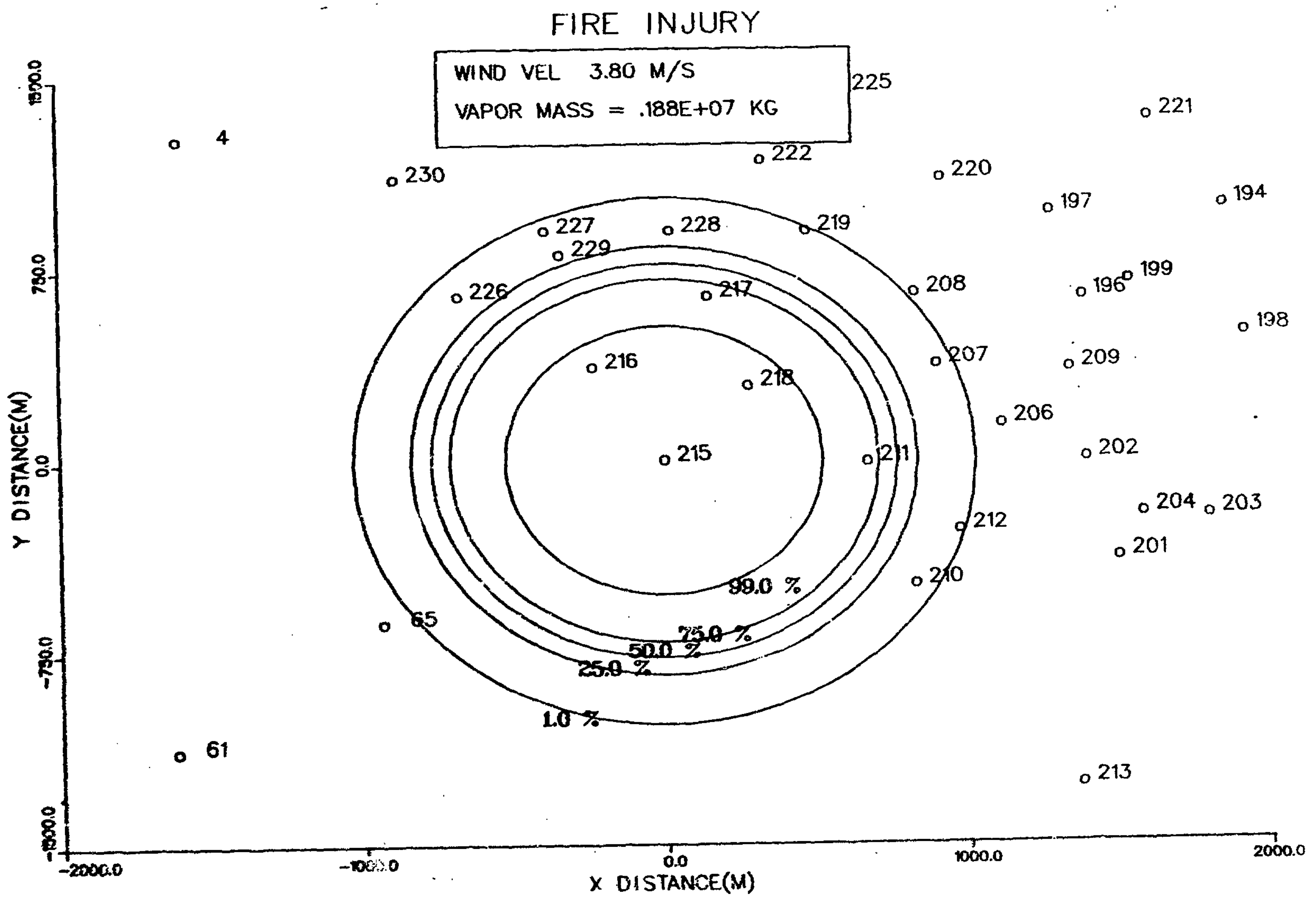


FIGURE 3-16. Fire Injury: LPG Spill/Coney Island

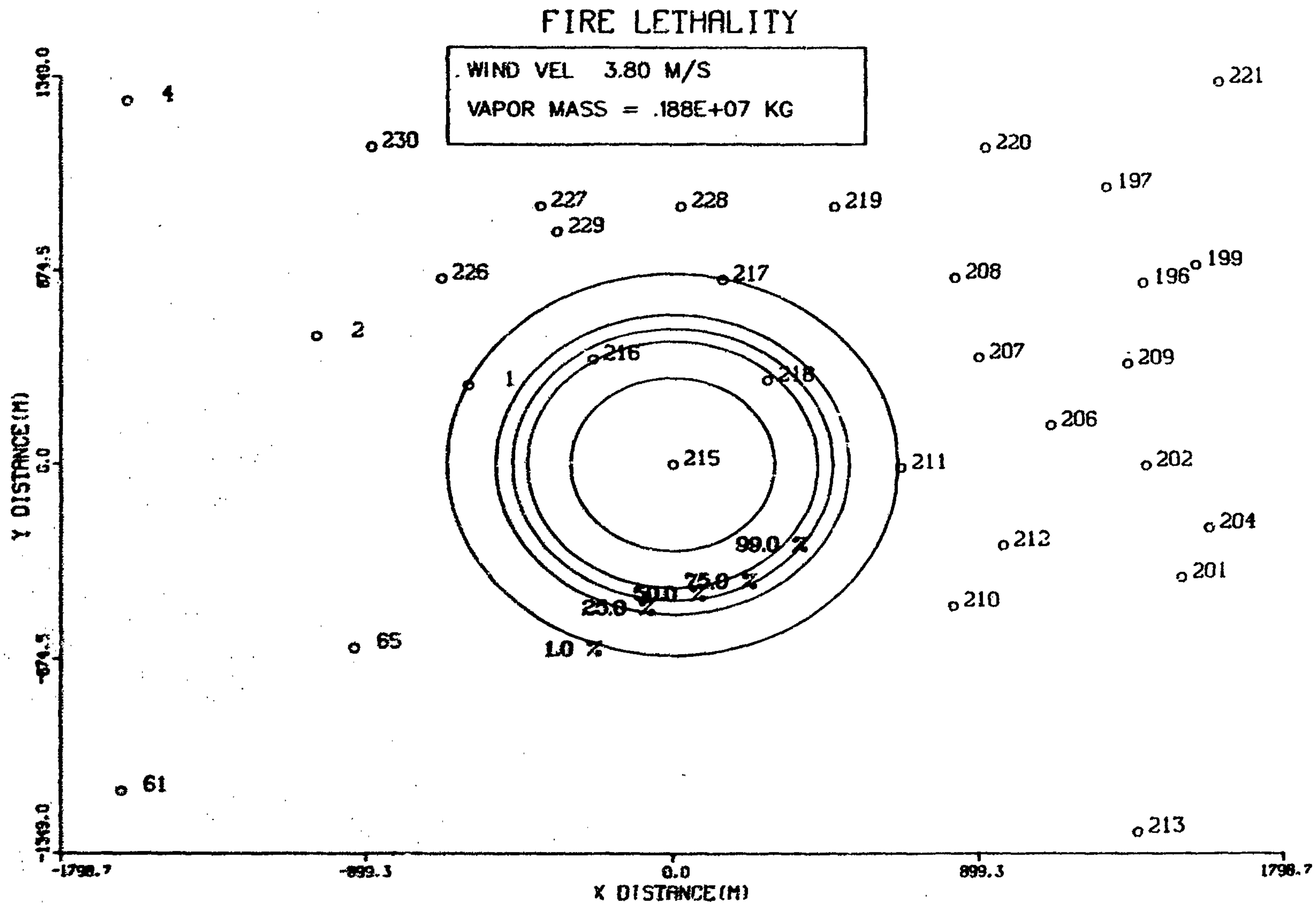


FIGURE 3-17. Fire Lethality: LPG Spill/Coney Island

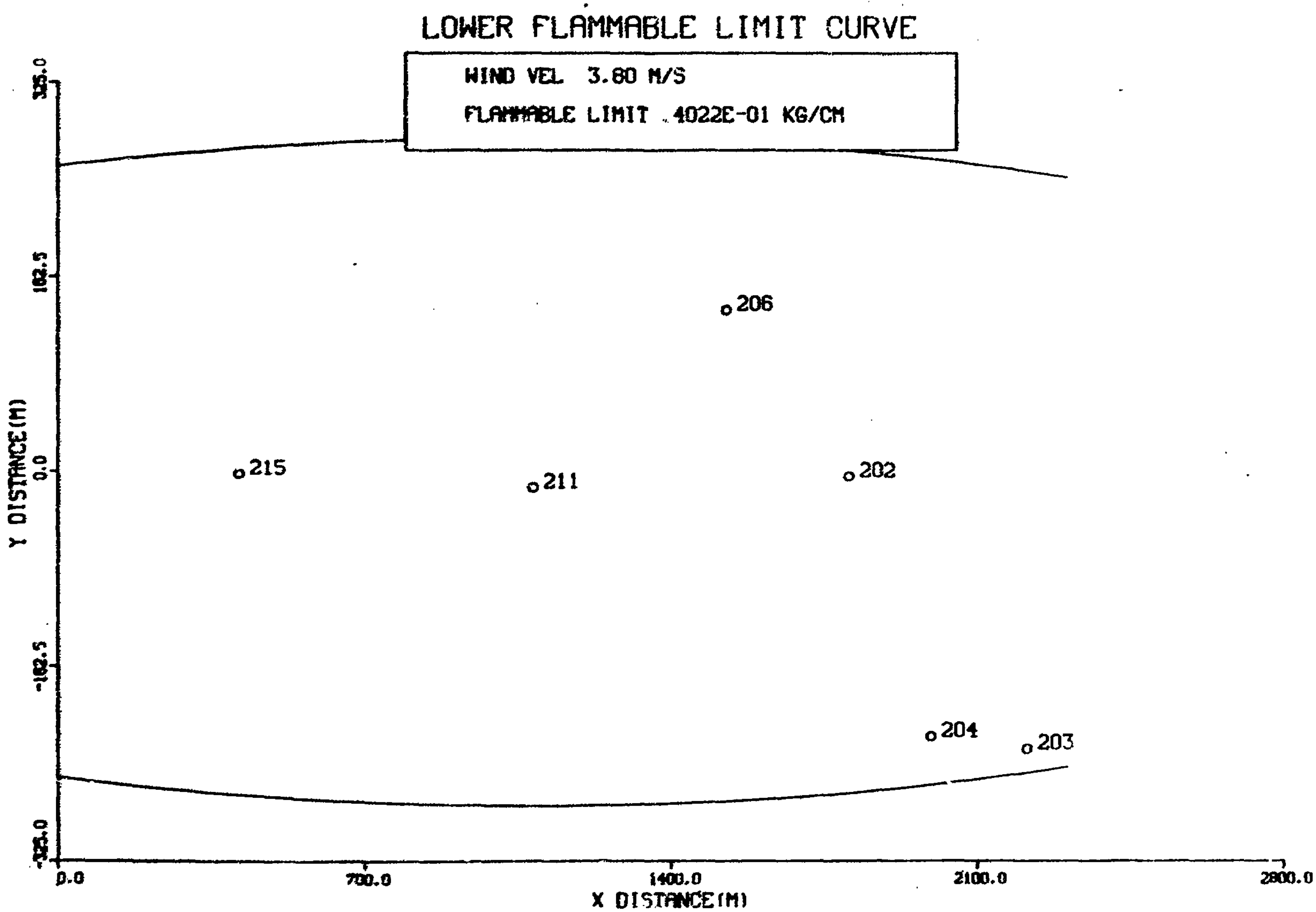


FIGURE 3-18. Lower Flammable Limit Curve: LPG Spill/Coney Island

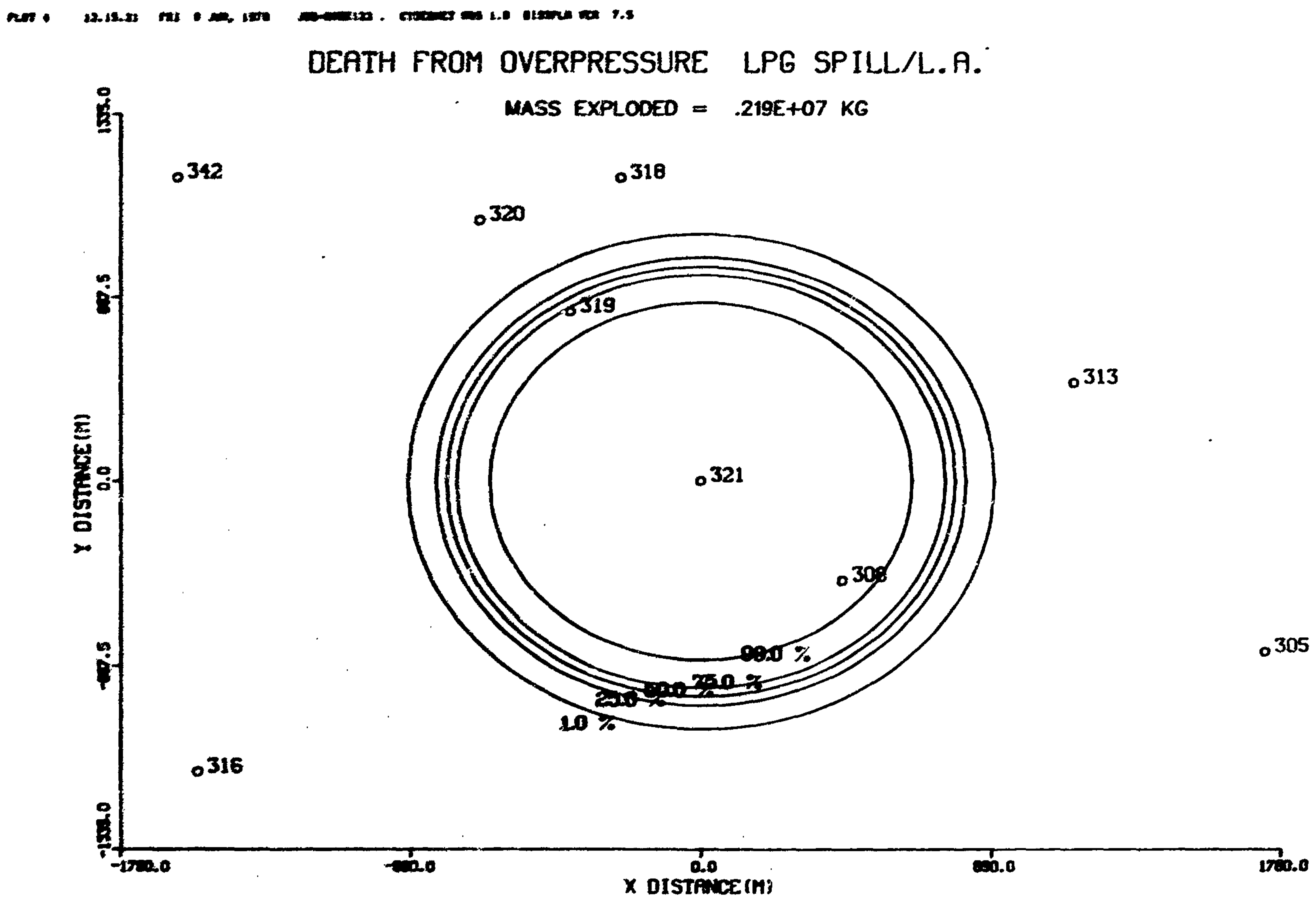


FIGURE 3-19. Death from Overpressure: LPG Spill/Los Angeles

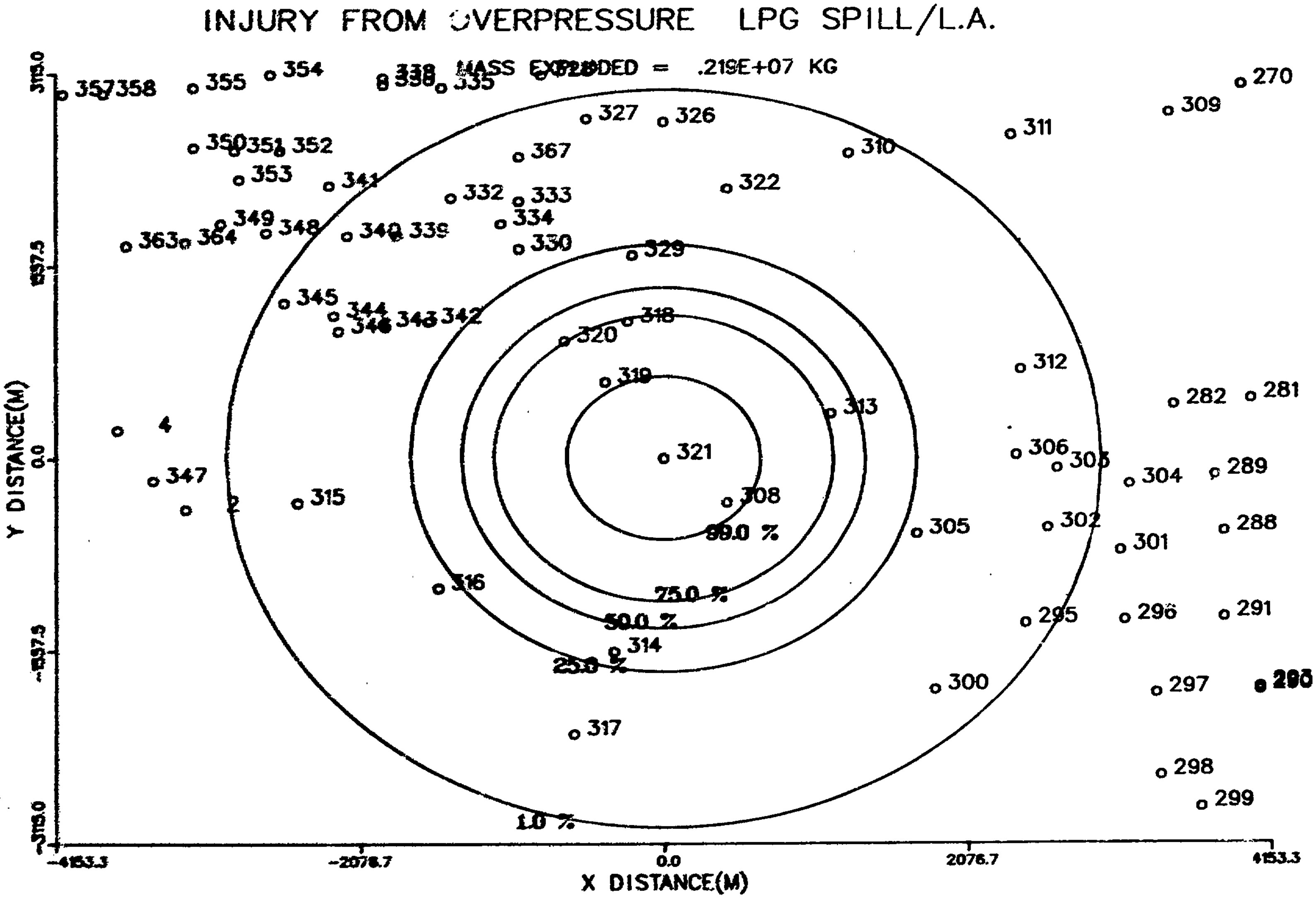


FIGURE 3-20. Injury from Overpressure: LPG Spill/Los Angeles

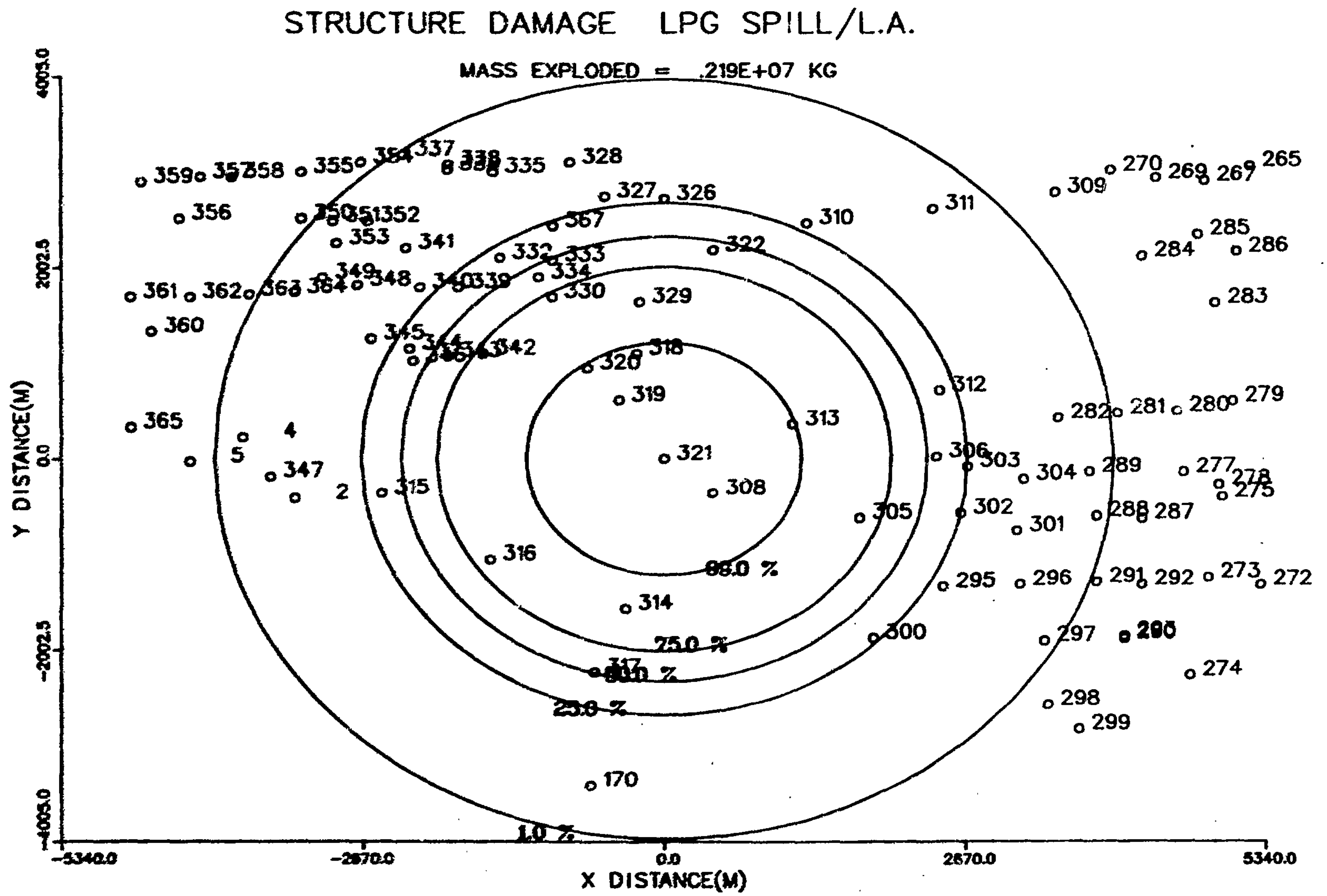


FIGURE 3-21. Structure Damage: LPG Spill/Los Angeles

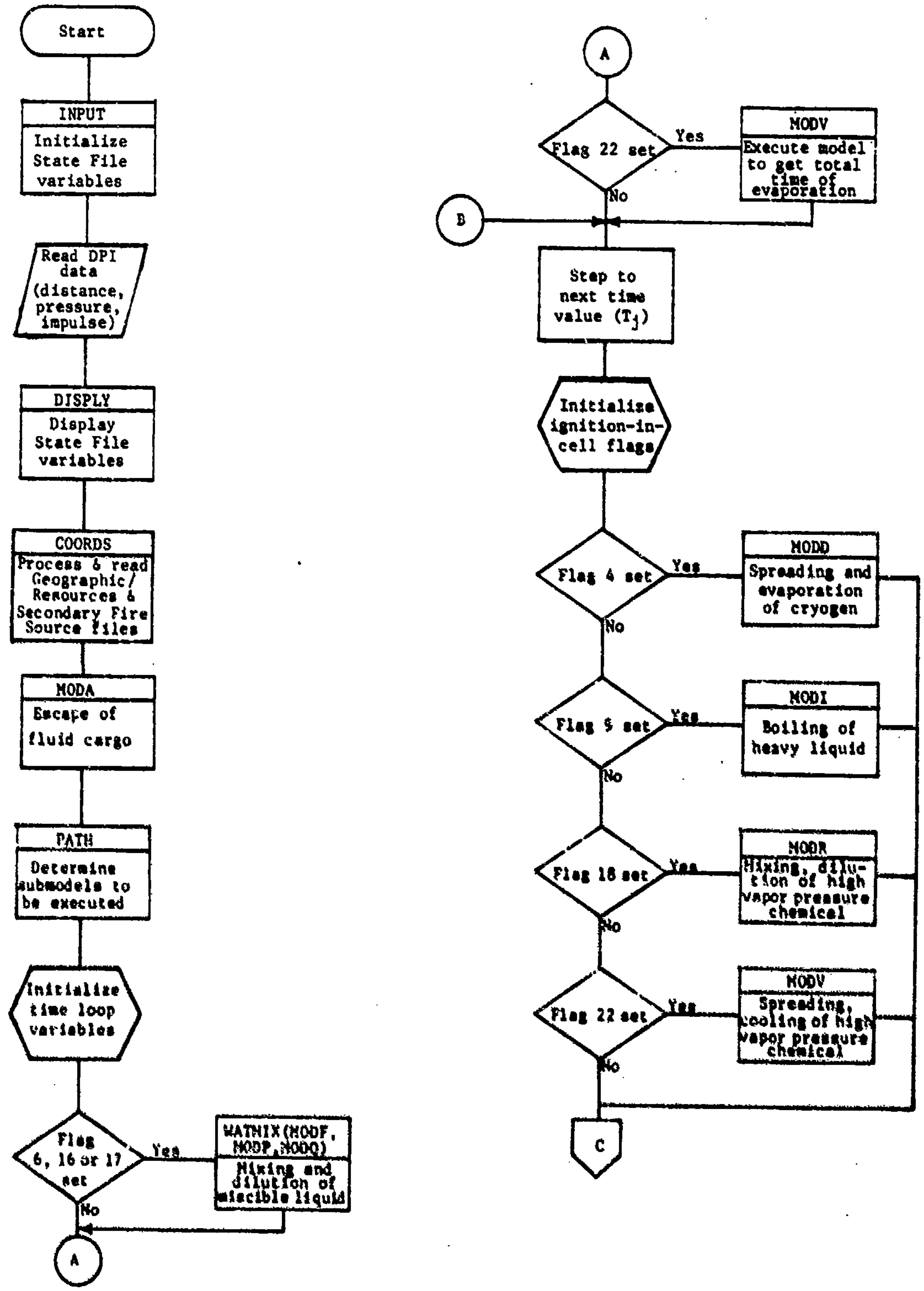


FIGURE 3-22. Flowchart of VN Executive Routine, VNEXEC

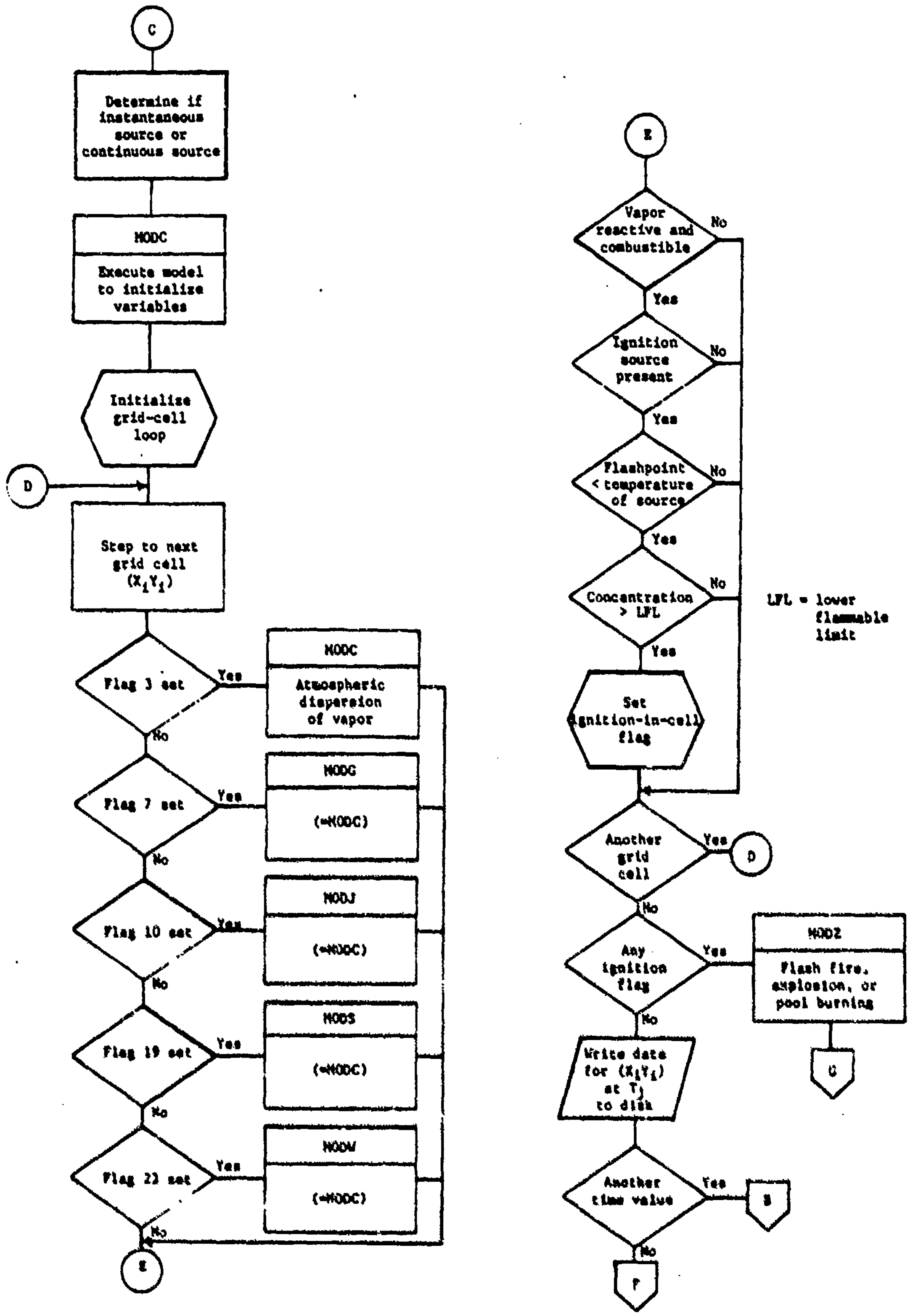


FIGURE 3-22 (continued)

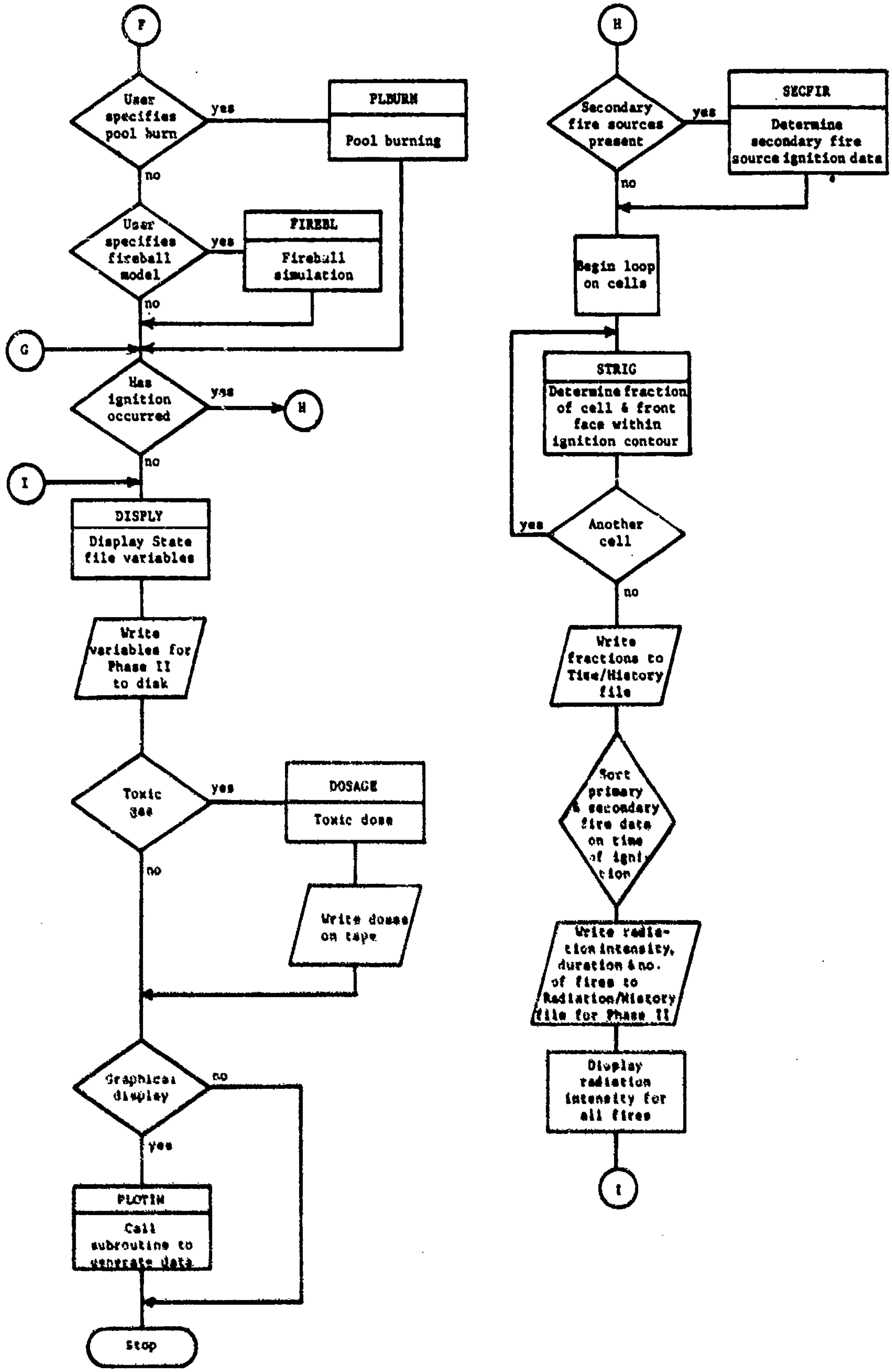


FIGURE 3-22 (concluded)

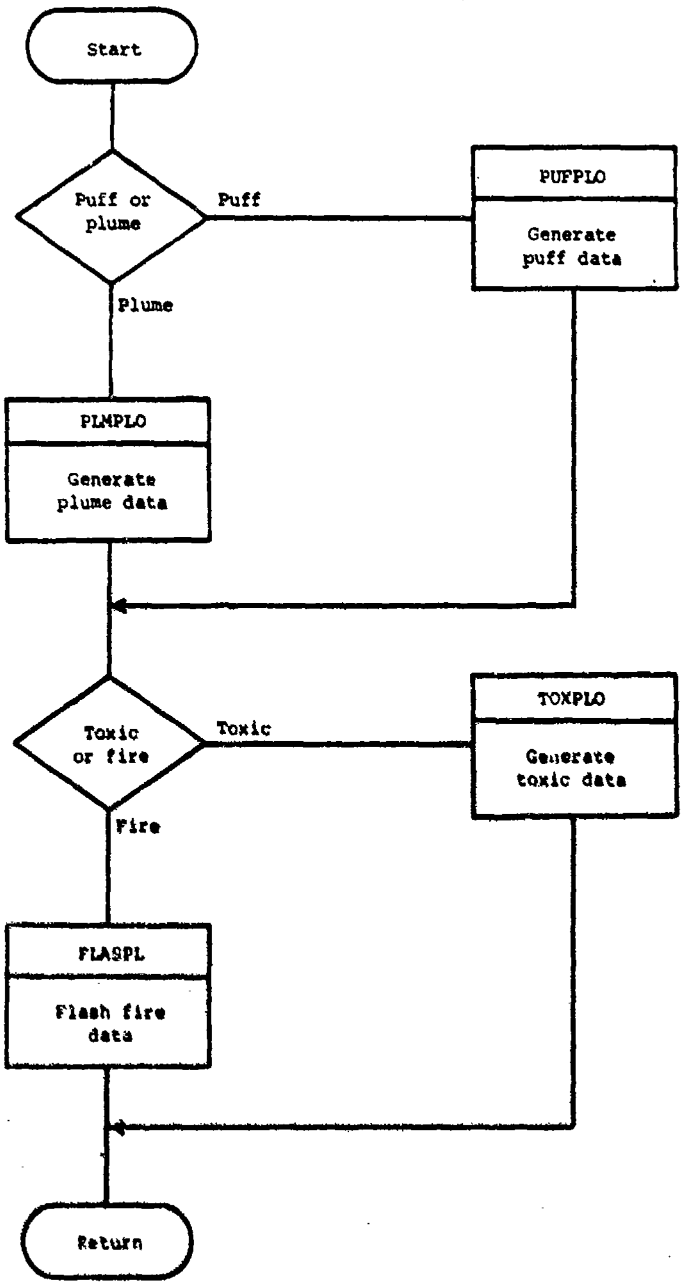


FIGURE 3-23. PLOTIN

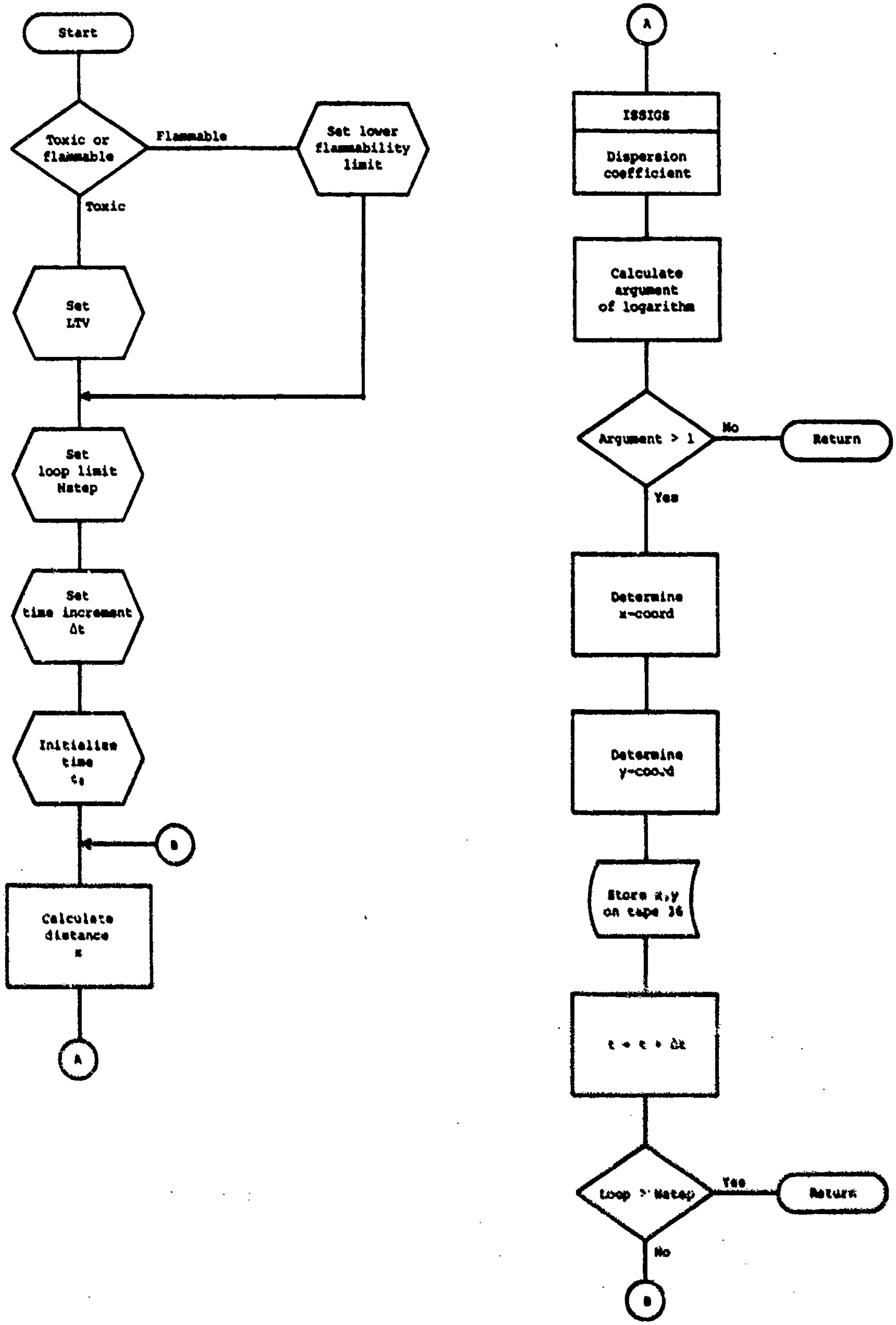


FIGURE 3-24. PUFPLO

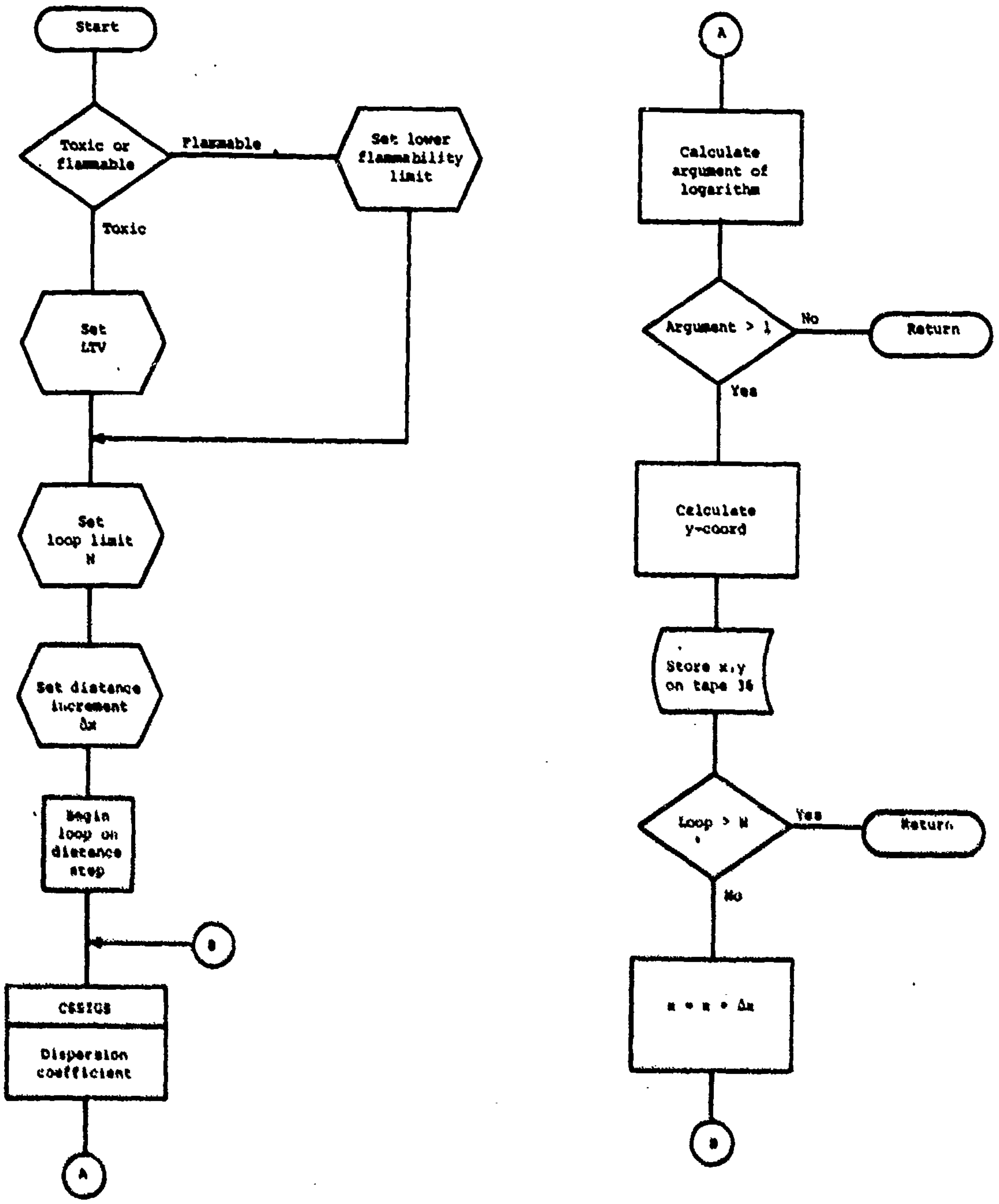


FIGURE 3-25. PLMPLO

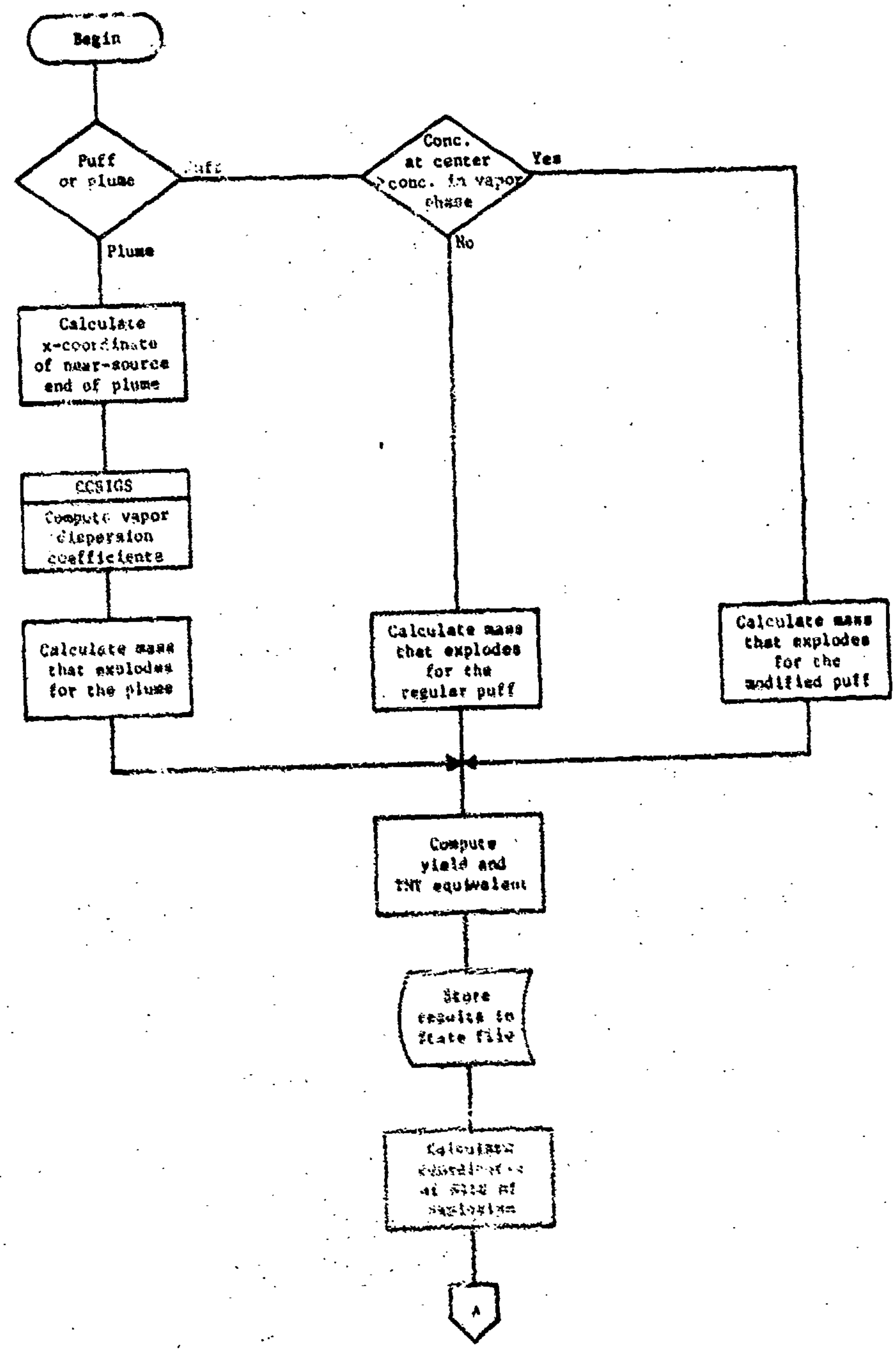


FIGURE 3-26. EXPLOD

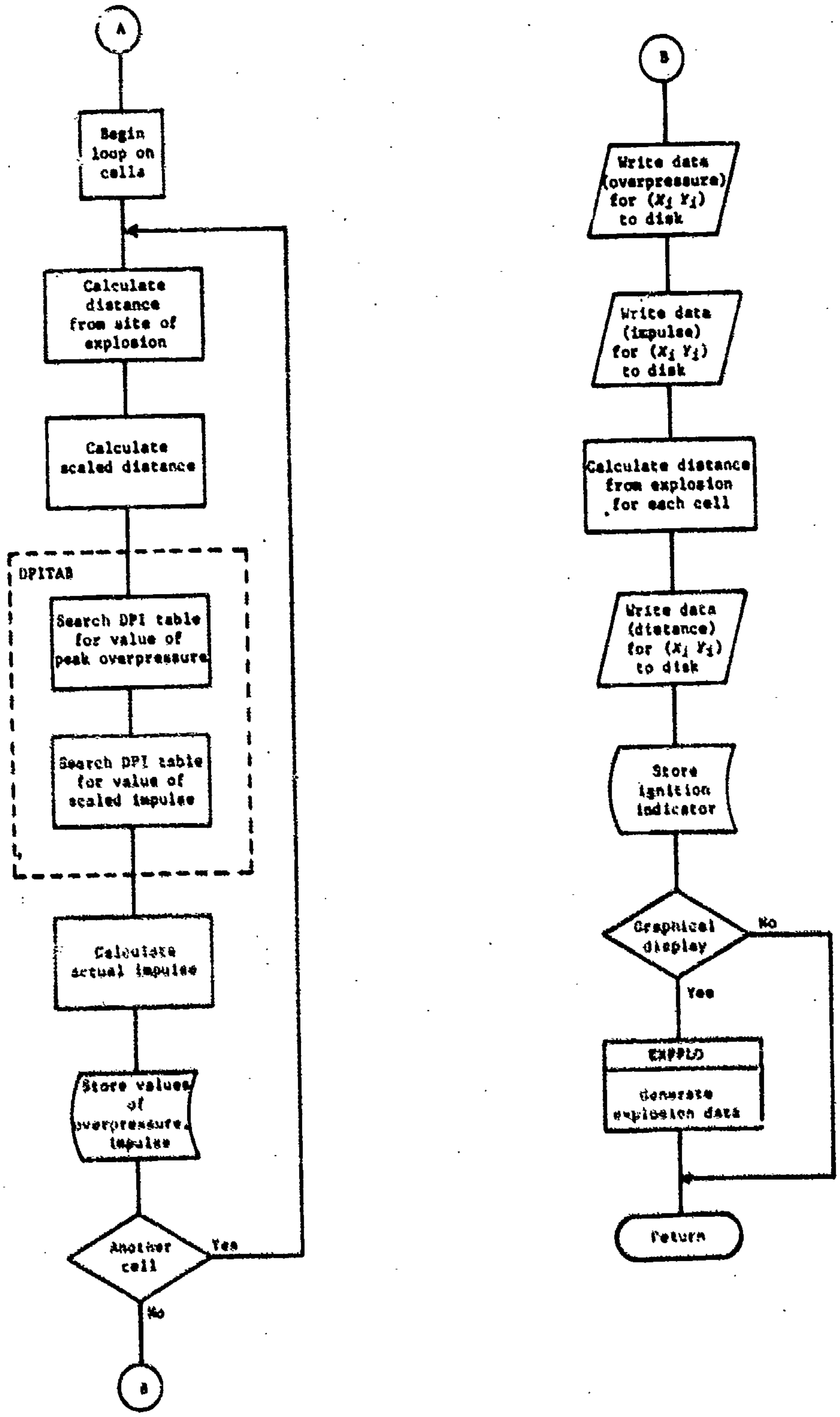


FIGURE 3-26 (concluded)

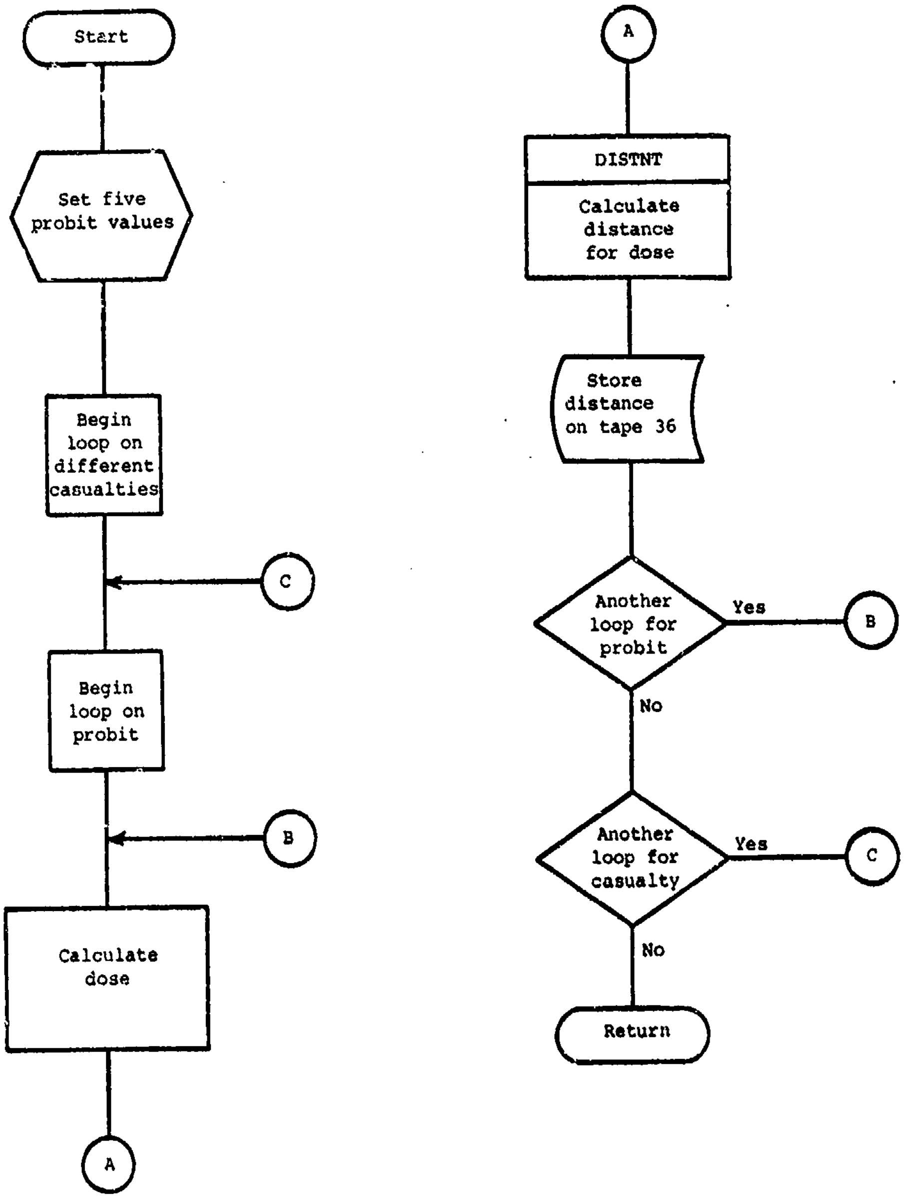


FIGURE 3-27. EXPPLO

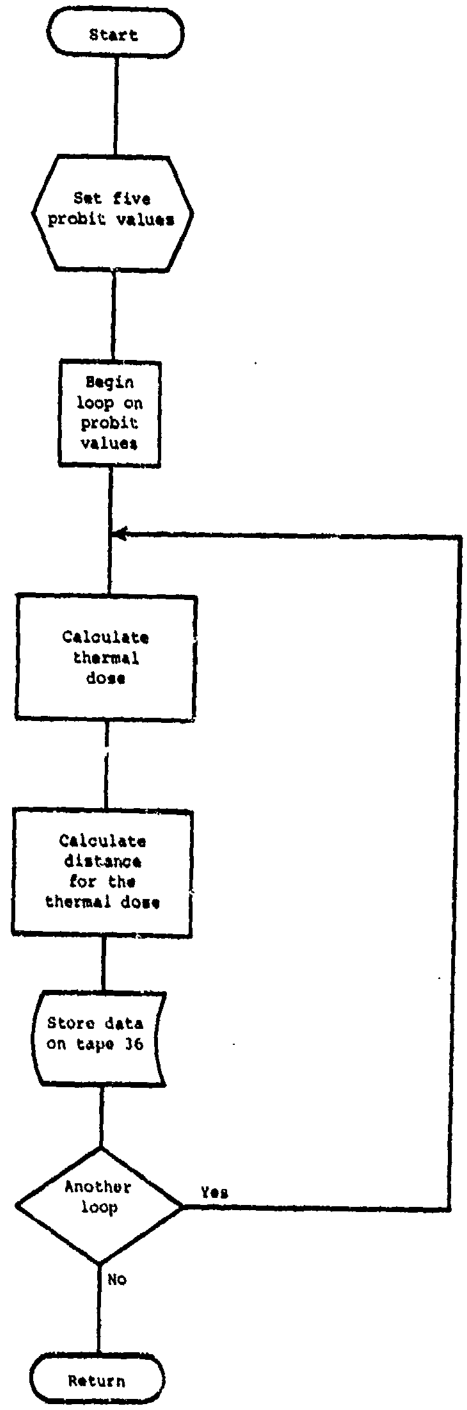


FIGURE 3-28. FLASPL

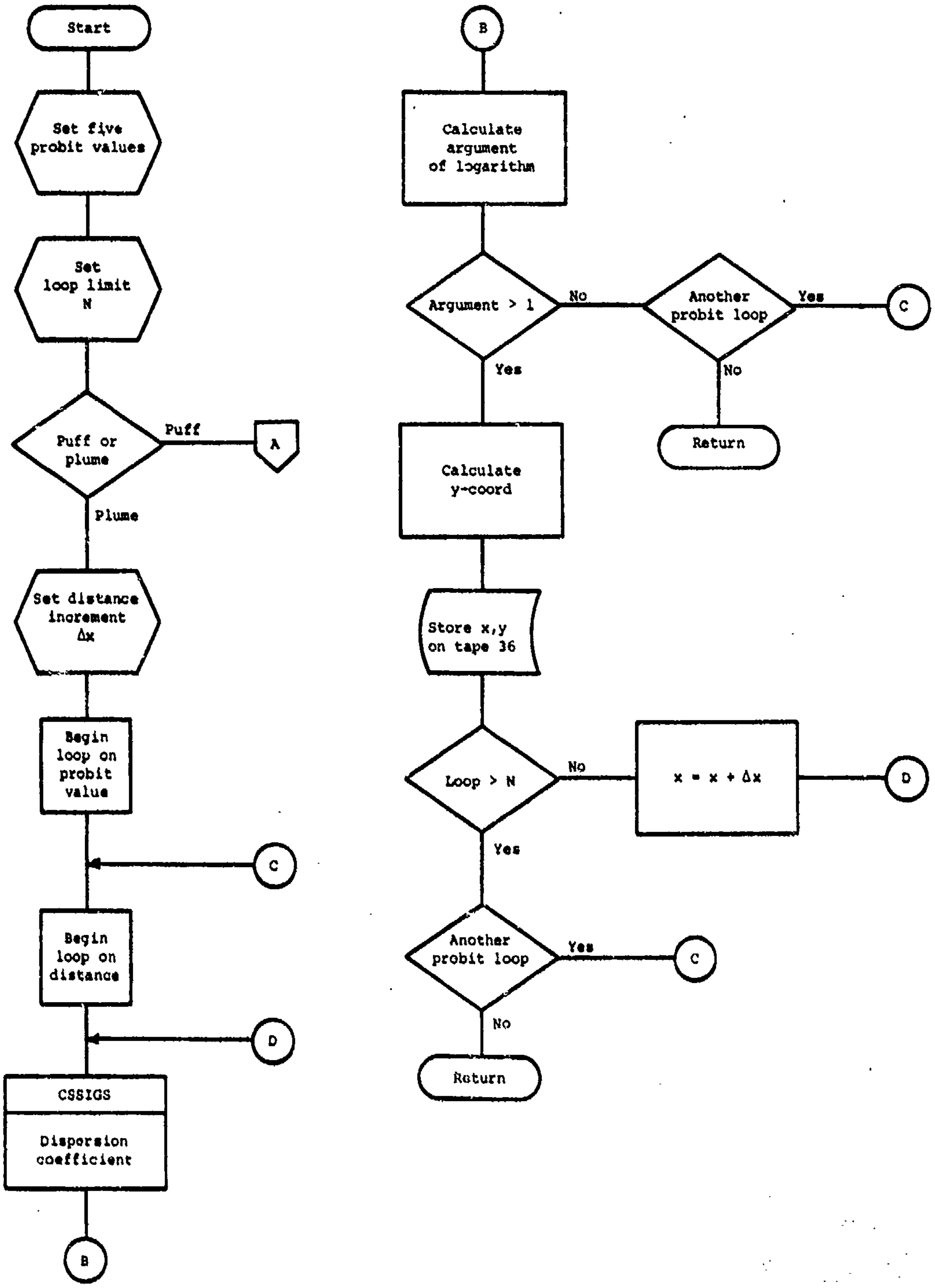


FIGURE 3-29. TOXPLO

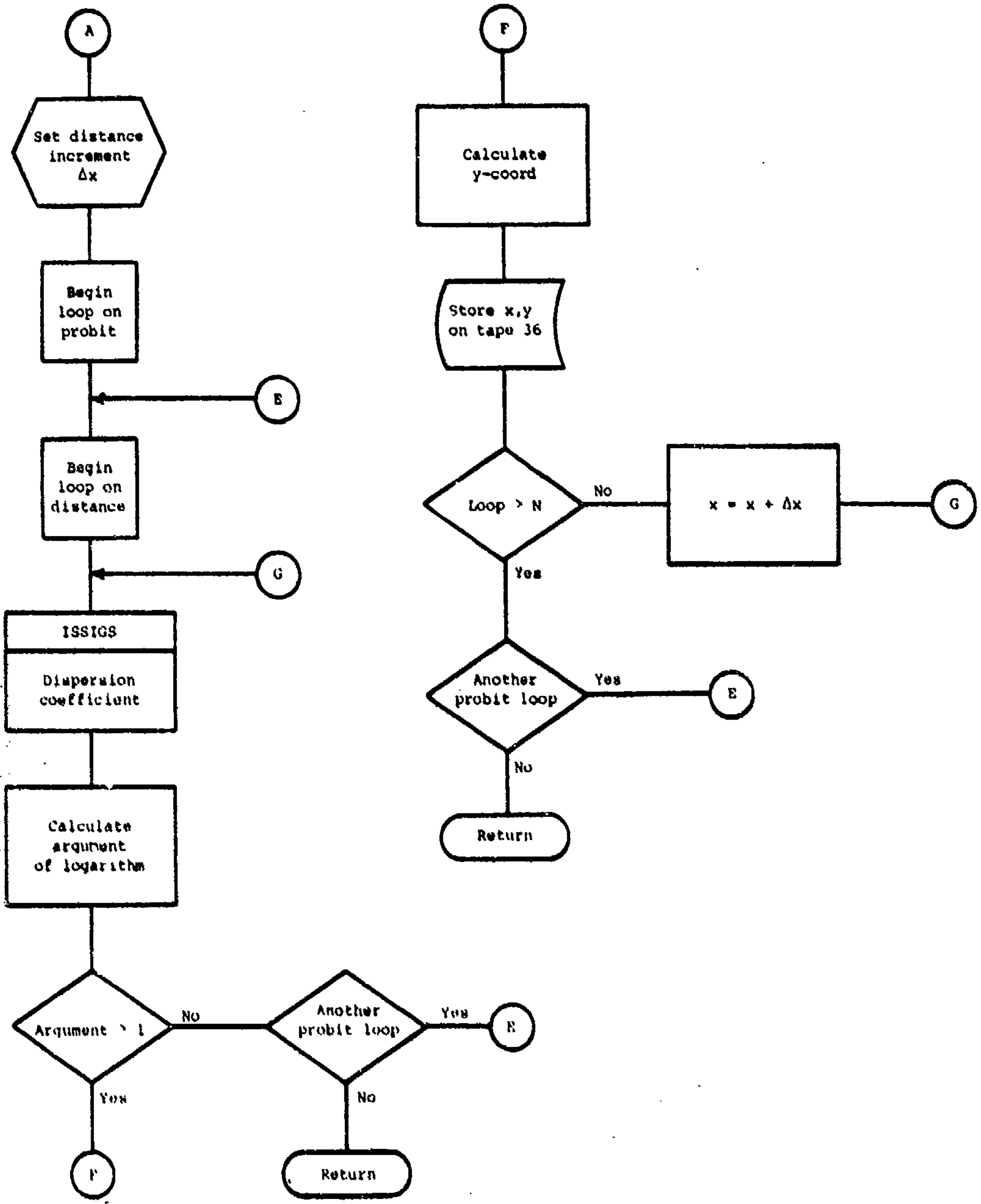


FIGURE 3-29 (concluded)

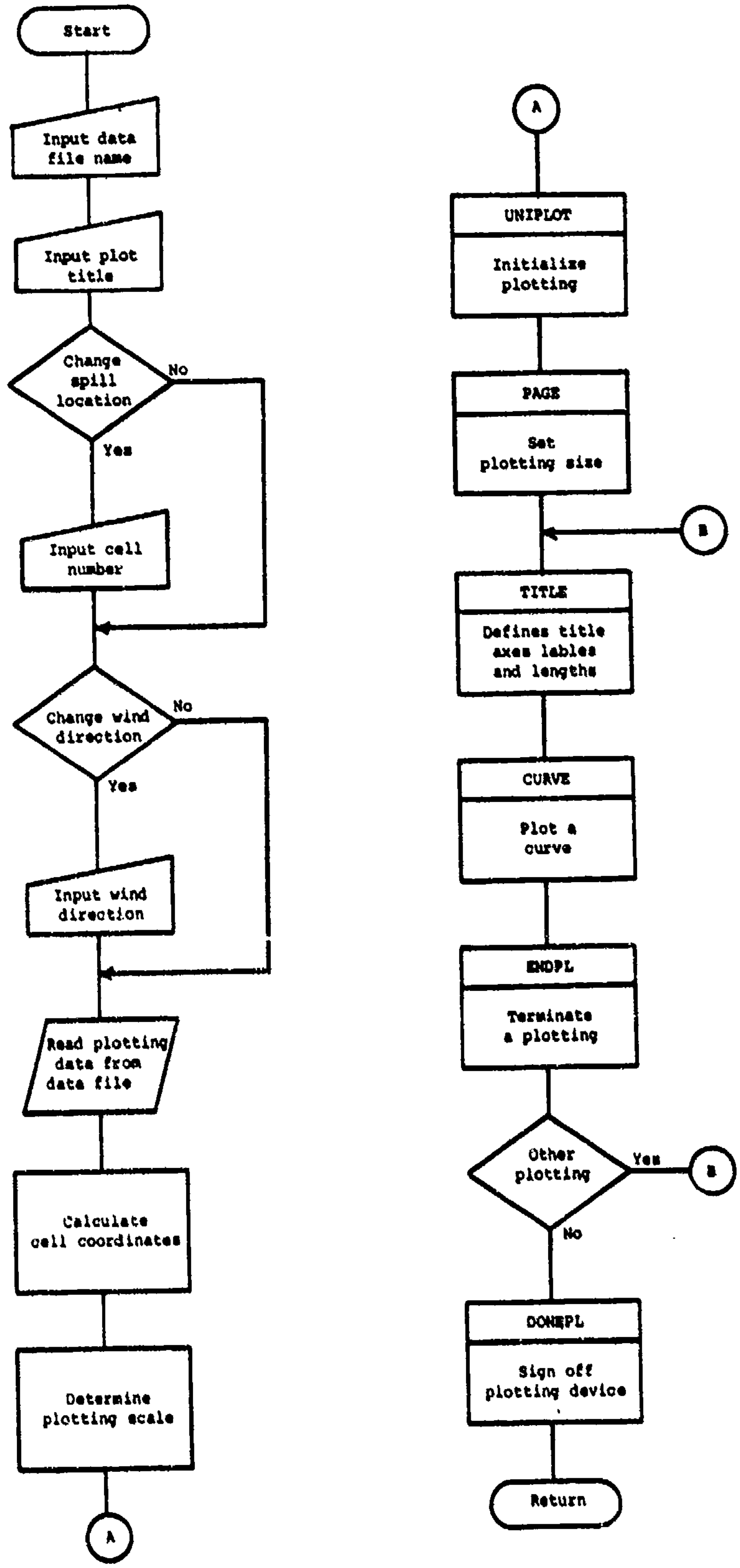


FIGURE 3-30. TOXDISP

Chapter 4

GEOGRAPHICAL/DEMOGRAPHIC FILE GENERATION FOR NEW YORK AND LOS ANGELES HARBORS

A. *INTRODUCTION*

Under Task 3 of this study to prepare the Vulnerability Model (VM) for operational use, two Geographical/Demographic files were generated for the New York Harbor and one file was generated for the Los Angeles Harbor area. Together with the previously created New Orleans file (GEONO1), there are now four files of several hundred cells each which can be accessed through the User Interface Module (UIM) or directly read into the VM.

The remainder of this chapter is devoted to descriptions of these files and discussion of how they were created.

B. *APPROACH*

The Geographical/Demographic files were generated by selective searches of census data contained within the U.S. Department of Commerce's Master Enumeration District List (MEDList). The data were provided on magnetic tapes arranged by census region, generally with two regions' data files per reel of tape.

The MEDList tapes contain census data arranged by state, then by county, then by census tract, and finally by enumeration district plus block group (if any). Our searches concentrated on extracting appropriate census tracts plus enumeration districts for targeting as cells in the Geographical/Demographic files. There is a great deal of other data available on these tapes concerning alternative code identifications for each tract. We selected the housing counts and population counts, and the latitude and longitude as well as the tract identification (tract number plus enumeration district number) for the Geographical files, and added to each line of extracted data an assumed ignition code of +3* (capable of igniting any material with flashpoint less than 200°F) and an assumed dollar value of $60,000 per structure per tract.

The latitudinal/longitudinal positions of each tract were used as keys for selection or rejection in making the searches. The objective of each search was to produce a file of 350 to 390 land area cells based on a presumed likely spill location, and then water area cells were added nearby the putative spill location to complete the file. Since the water cells are critical in establishing whether or not the program will even compute the cause of a spill, a fairly wide expanse of water was used to locate these cells so as to provide the VM user with flexibility in selecting

*Except for the water cells of the Los Angeles and two New York area files, to which were assigned ignition codes of zero (no potential to ignite).

spill locations. (The criterion used in the VM for going ahead with computations is that the selected spill location must be within 20 seconds of latitude or longitude of a cell—20 seconds is about one-third of a mile or about 0.53 kilometers.)

Each generated Geographical file was then given a systematically determined name and UIM code. The names are based on the abbreviation of the port city that was the basis for selecting the tract cells, prefixed by the syllable GEO and suffixed by an identifying digit which corresponded to the sequential order in which the file was made. The files generated were:

- GEOLA1
- GEONY4
- GEONY6

C. *DESCRIPTIONS OF FILES*

The GEOLA1 file was produced for the Long Beach area of Los Angeles, California. There are 361 land area cells and 6 water area cells, for a total of 367 cells. The file covers an area 9 miles north, 2 miles west, and 8 miles east of a putative spill site in the San Pedro Harbor, with coordinates of 33°42'34" N. and 118°16'19" W. On land, it extends northward to Lakewood, eastward to the Long Beach Airport, and westward to the Torrance Municipal Airport. The resulting area of coverage resembles a square. Figure 4-1 is a map of the Los Angeles area showing the boundaries of this file. Figure 4-2 is a map of the harbor area showing the location of the census tracts contained in the file. In general, each tract contains several block groups which constitute the individual cells in the file.

Figure 4-3 is a map of the New York Harbor area showing the location of the two Geographical files created for that area. Figures 4-4 and 4-5 are large-scale maps showing the location of the census tracts that make up the GEONY4 and GEONY6 files, respectively. Again, each census tract is composed of several cells (block groups).

The GEONY4 file was produced for the Perth Amboy, New Jersey/New York area. There are 358 land area cells and 6 water area cells, for a total of 364 cells, in this file. The area of coverage is a cut square, of side and length equal to 16 miles, centered about a hypothetical spill site located at 40°30'40" N. and 74°15'35" W. On land, it extends northward to an imaginary line connecting Plainfield and Linden, N.J., westward to Edison, N.J., and southward to Browntown, N.J.; the eastern boundary varies—it is approximately at Grasmere in New York and at the Middlesex-Monmouth County lines in New Jersey.

The GEONY6 file was produced for the South Brooklyn-Coney Island/New York area. There are 380 land area cells and 6 water area cells, for a total of 386 cells, in this file. The area of coverage is a rectangle

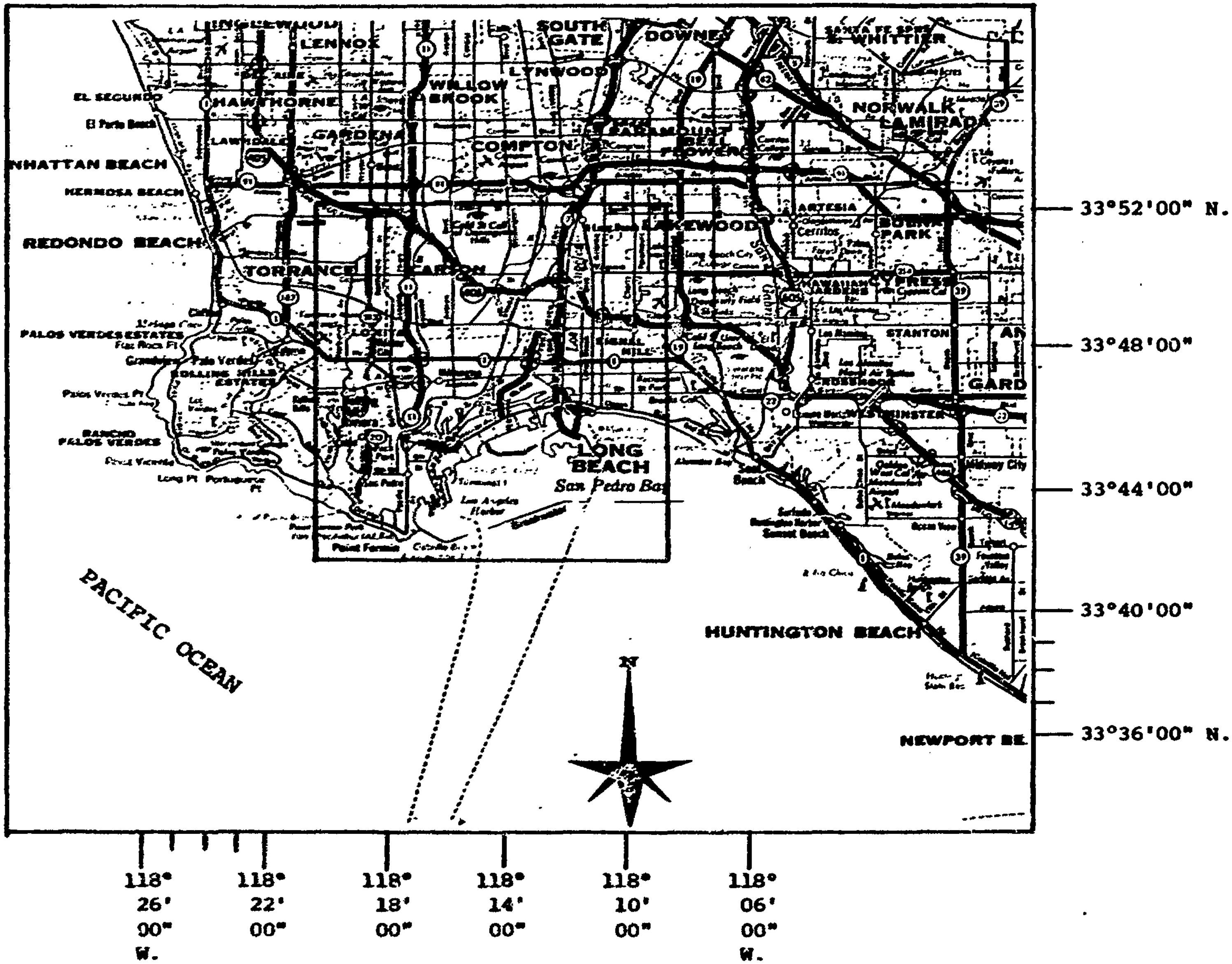


FIGURE 4-1. Reference Map for the Los Angeles File (GEOLA1)

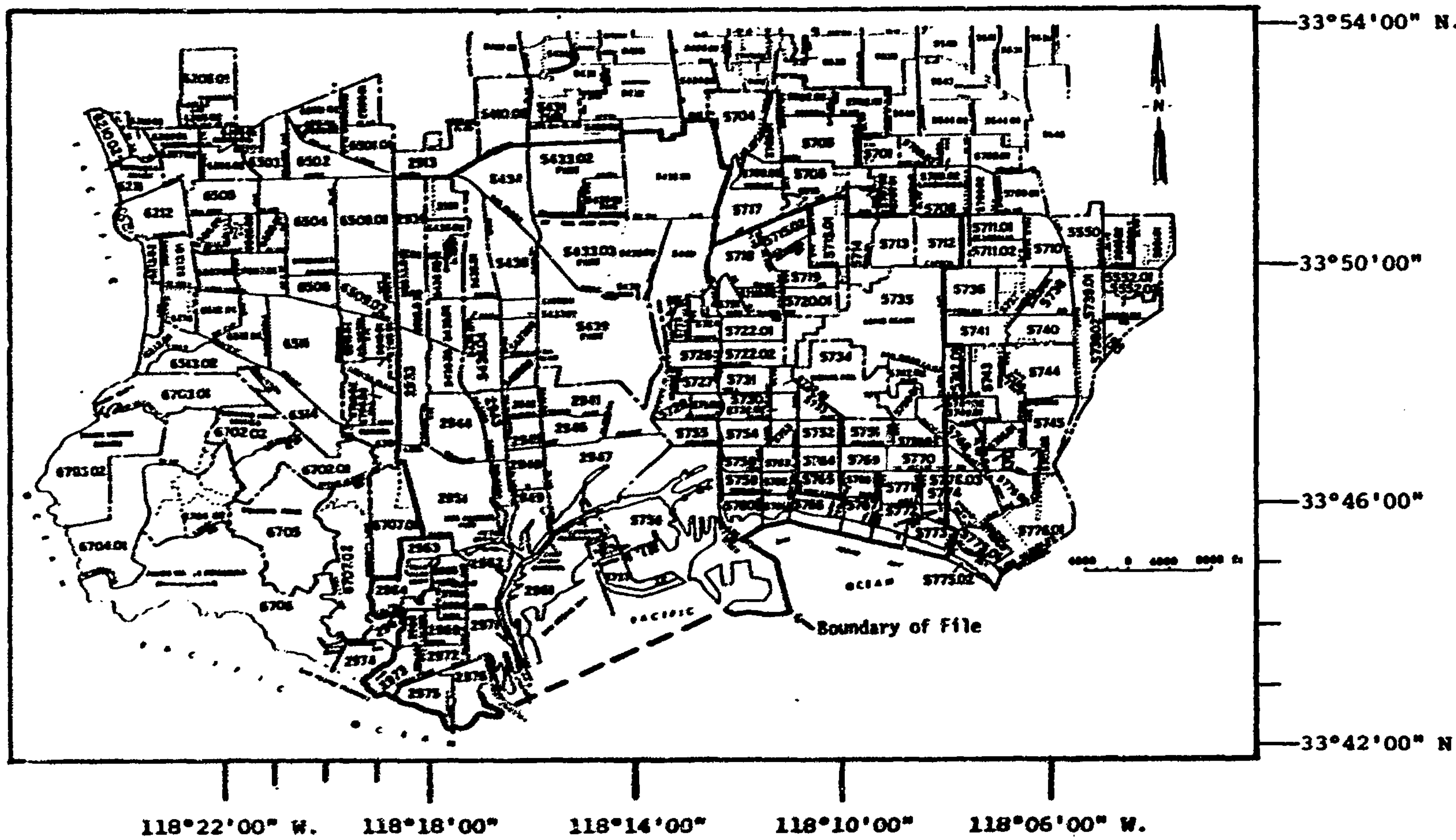


FIGURE 4-2. GEOLA1

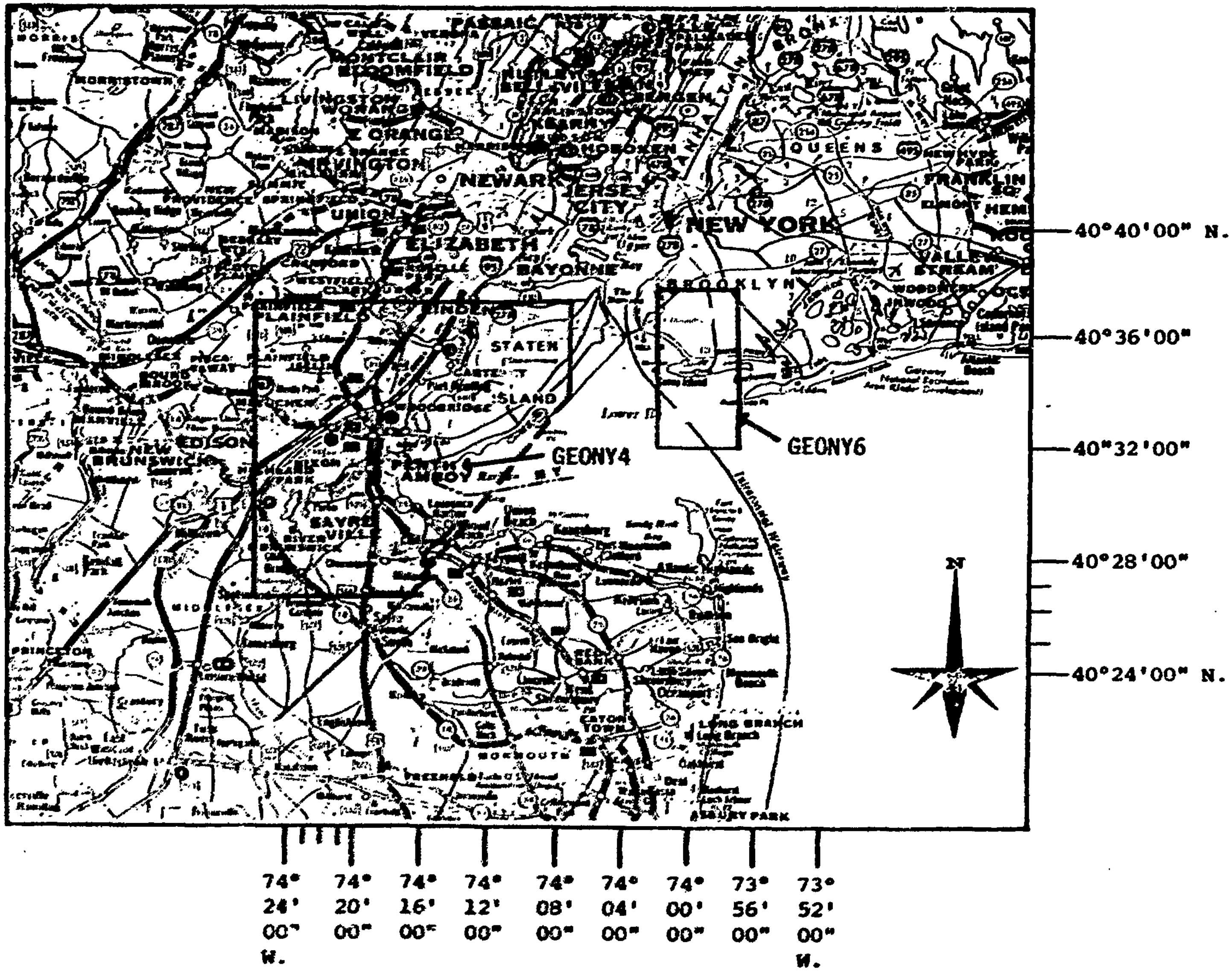


FIGURE 4-3. Reference Map for Both New York Files (GEONY4 & GEONY6)

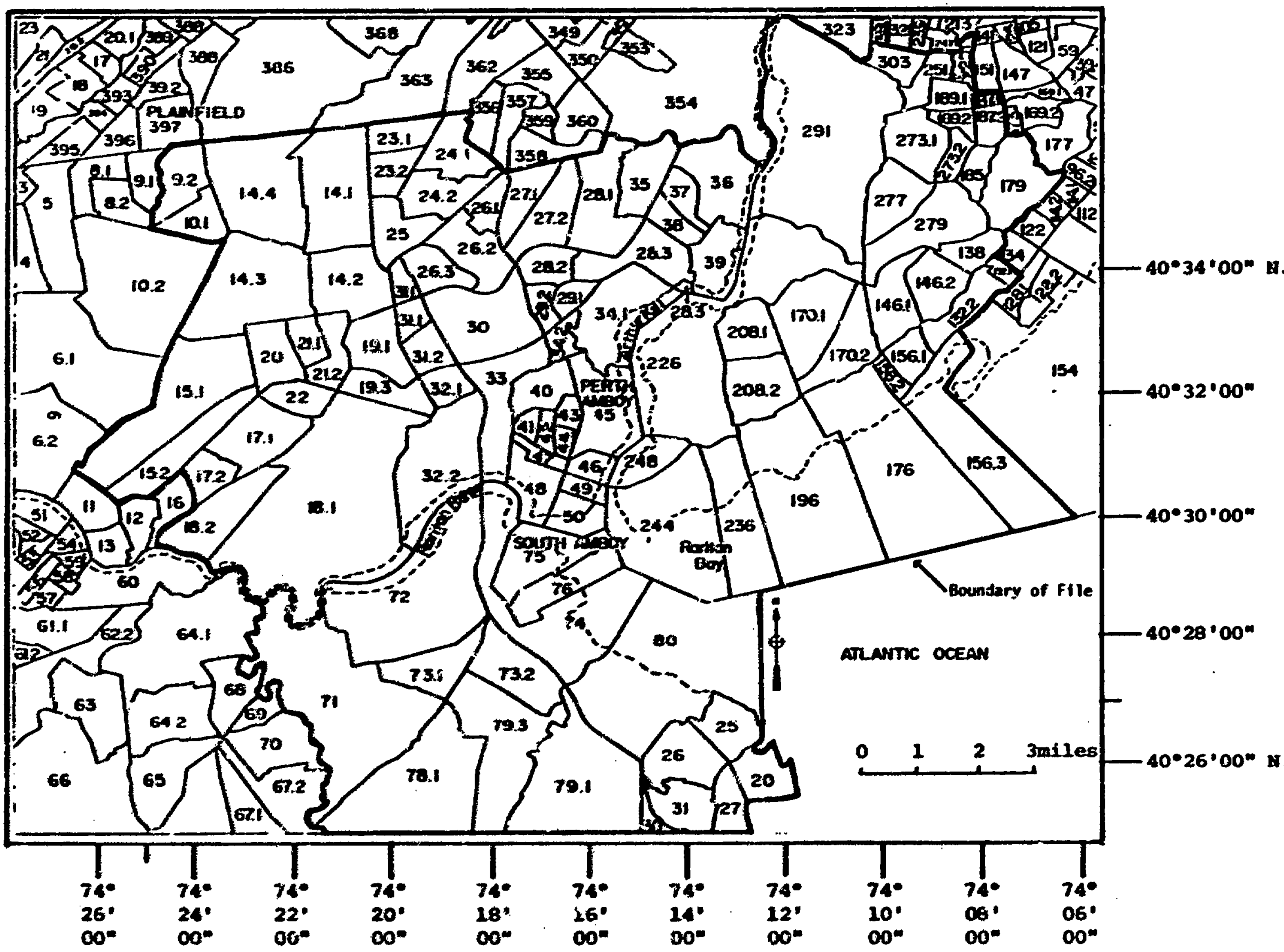


FIGURE 4-4. GEONY4

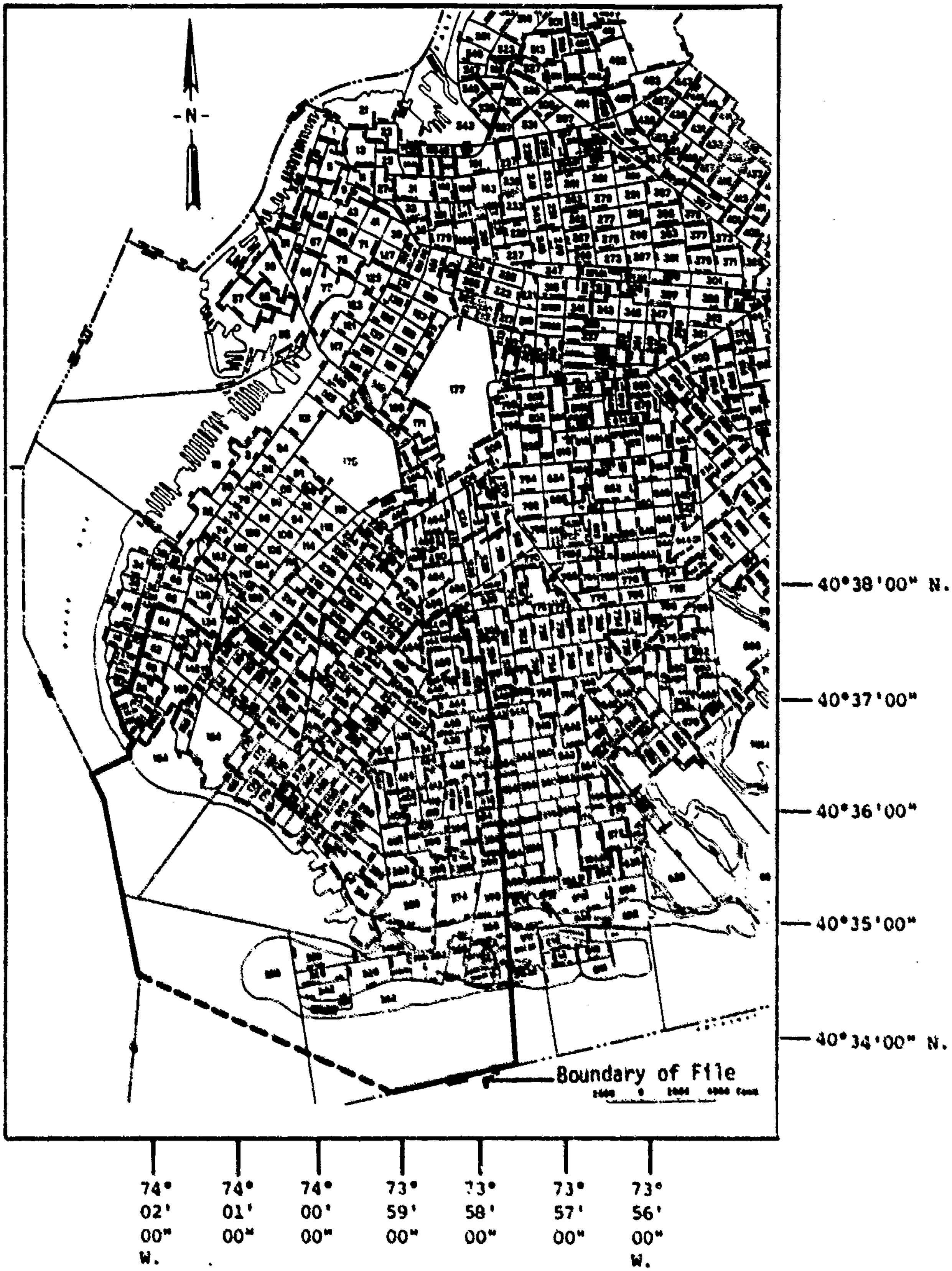


FIGURE 4-5. GEONY6

with long sides equal to 7 miles and short sides equal to 4 miles. The southern base of the square has a midpoint at 40°31'24" N. and 74°00'00" W. It extends northward to the center of Prospect Park, eastward to Brooklyn College (CUNY), and westward to Owls Head Park. The southern terminus is at an imaginary line approximately 3 miles south of the Coney Island shore-line.

A previously created file, GEONO1, exists for New Orleans, Louisiana. There are 252 land area cells and 84 water area* cells, for a total of 336 cells, in this file. The reason for the great number of water area cells is the fact that the water body of interest, the Mississippi River, cross-cuts the city; thus, this is a case where numerous water cells are needed to provide the user with flexibility in selecting potential spill sites for modeling (whereas in New York and Los Angeles, the geographical areas primarily cover short strips of shoreline, for which only a few possible spill sites exist). The area of coverage is approximately 9 miles square and is bounded to the north by Lake Pontchartrain's southern shoreline, to the east by Arabi, to the west by Metairie, and to the south by a line extending approximately parallel with the Mayonne Canal. A map of GEONO1 is presented as Figure 4-6.

Since the user of any of these files is bound to the criterion that the selected spill site must be within 20 seconds of latitude or longitude of any (water) cell, Table 4-1 presents the coordinates of the water cells developed for these files.

For linkage to the UIM, four-digit codes have been assigned to each file. The codes were assigned on the basis of state numbers as they occur in the MEDList tapes, the port city number associated with each state, and the sequential number of the file belonging to each port city. The table of codes is displayed below:

TABLE OF UIM CODES

Port City	File Name	UIM Code
New York	GEONY4	3611
New York	GEONY6	3612
New Orleans	GEONO1	2211
Los Angeles	GEOLA1	1611

*All of which have ignition codes of +3.

TABLE 4-1

Coordinates of Water Area Cells Associated with Each Geographical File

FILE	WATER CELL ID	LATITUDE	LONGITUDE
GEONY4	R01	40°30'30"	74°15'40"
	R02	40°30'15"	74°15'35"
	R03	40°29'00"	74°15'35"
	R04	40°29'45"	74°15'50"
	R05	40°29'20"	74°15'30"
	R06	40°29'15"	74°15'00"
GEONY6	R01	40°31'50"	74°00'00"
	R02	40°32'20"	74°00'00"
	R03	40°33'00"	74°00'00"
	R04	40°33'30"	74°00'00"
	R05	40°34'00"	74°00'00"
	R06	40°34'10"	74°00'00"
GEOLA1	R01	33°43'25"	118°11'00"
	R02	33°43'15"	118°16'00"
	R03	33°44'00"	118°11'00"
	R04	33°43'00"	118°16'25"
	R05	33°42'45"	118°16'15"
	R06	33°44'00"	118°12'00"
GEONO1	R1	29°58'00"	90°15'10"
	R2	29°58'02"	90°15'20"
	R3	29°58'02"	90°15'00"
	R04	29°57'40"	90°14'20"
	R05	29°57'20"	90°13'40"
	R06	29°56'40"	90°13'30"
	R07	29°56'20"	90°13'20"
	R08	29°55'50"	90°13'10"
	R09	29°55'30"	90°13'00"
	R10	29°55'20"	90°12'50"
	R11	29°55'20"	90°12'30"
	R12	29°55'20"	90°12'00"
	R13	29°55'20"	90°11'40"
	R14	29°55'30"	90°11'20"
	R15	29°55'40"	90°11'00"
	R16	29°56'00"	90°10'40"
	R17	29°56'10"	90°10'30"
	R18	29°56'40"	90°10'00"
	R19	29°57'00"	90°09'40"
	R20	29°57'10"	90°09'20"
	R21	29°57'20"	90°09'00"
	R22	29°57'20"	90°08'40"
	R23	29°57'00"	90°08'30"
	R24	29°56'40"	90°08'30"
	R25	29°56'20"	90°08'30"
	R26	29°56'00"	90°08'30"
	R27	29°55'40"	90°08'30"
	R28	29°55'30"	90°08'30"
	R29	29°55'20"	90°08'30"
	R30	29°55'00"	90°08'20"
	R31	29°54'40"	90°08'10"
	R32	29°54'30"	90°07'40"
	R33	29°54'30"	90°07'35"
GEONO1	R34	29°54'30"	90°07'00"
	R35	29°54'30"	90°06'30"
	R36	29°54'40"	90°06'00"
	R37	29°54'40"	90°05'40"
	R38	29°54'40"	90°05'10"
	R39	29°55'00"	90°04'40"
	R40	29°55'00"	90°04'20"
	R41	29°55'20"	90°04'00"
	R42	29°55'30"	90°03'40"
	R43	29°55'50"	90°03'30"
	R44	29°56'10"	90°03'20"
	R45	29°56'20"	90°03'30"
	R46	29°56'40"	90°03'30"
	R47	29°57'00"	90°03'30"
	R48	29°57'10"	90°03'30"
	R49	29°57'20"	90°03'20"
	R50	29°57'40"	90°03'00"
	R51	29°57'40"	90°03'40"
	R52	29°57'30"	90°02'20"
	R53	29°57'20"	90°02'00"
	R54	29°57'20"	90°01'40"
	R55	29°57'00"	90°01'30"
	R56	29°56'40"	90°01'20"
	R57	29°56'40"	90°00'40"
	R58	29°56'30"	90°00'30"
	R59	29°56'20"	90°00'00"
	R60	29°56'20"	90°59'40"
	R61	29°56'00"	90°59'30"
	R62	29°55'50"	90°59'10"
	R63	29°55'30"	90°58'50"
	R64	29°55'30"	90°59'10"
	R65	29°55'30"	90°58'10"
	R66	29°55'30"	90°57'40"
	R67	29°55'30"	90°57'20"
	R68	29°55'20"	90°57'00"
	R69	29°55'20"	90°56'30"
	R70	29°55'20"	90°56'00"
	R71	29°55'20"	90°55'50"
	R72	29°55'20"	90°55'40"
	R73	29°55'00"	90°55'30"
	R74	29°54'40"	90°55'20"
	R75	29°54'20"	90°55'00"
	R76	29°54'00"	90°54'40"
	R77	29°53'40"	90°54'30"
	R78	29°53'30"	90°54'20"
	R79	29°53'00"	90°54'20"
	R80	29°52'40"	90°54'20"
	R81	29°52'30"	90°54'20"
	R82	29°52'20"	90°54'30"
	R83	29°52'00"	90°54'40"
	R84	29°52'00"	90°55'00"

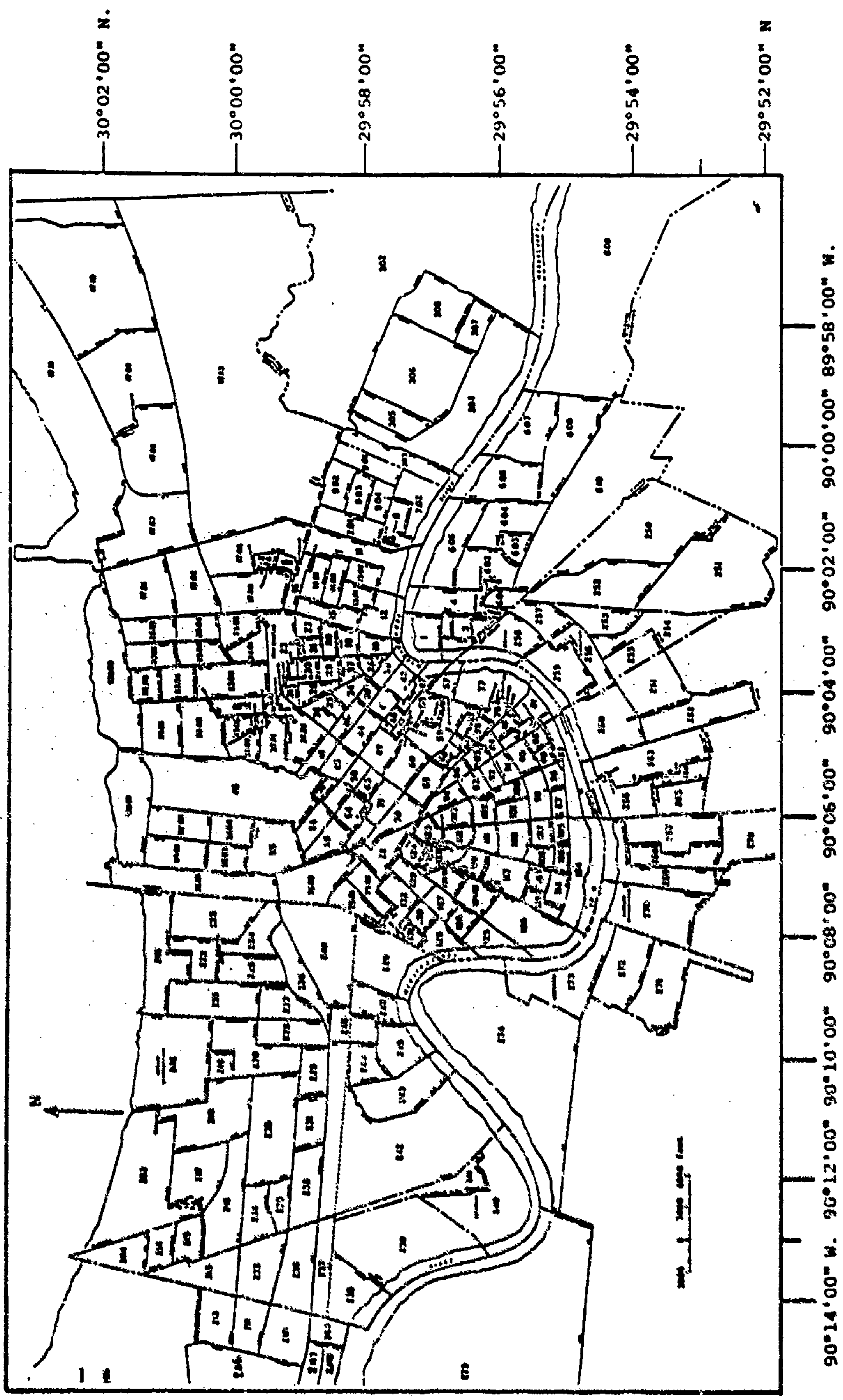


FIGURE 4-6. GEON01

D. PROBLEMS ENCOUNTERED

The tapes were searched on the basis of state and county codes as well as latitude/longitude boundaries to produce the Geographical/Demographic files. Although no major computer-related problems were encountered, there were some intersystem incompatabilities that had to be dealt with.

In particular, the tapes were originally made on IBM equipment. Since four of the five tapes contained two-region files, it was necessary to "read" past tape-file markers placed on these tapes to serve as separators. On IBM systems, a double tape mark is placed between files to act as the separator; on CDC systems, only single marks are used in this case, and a double mark signals "end of information" on a tape and cannot be read past by the software. Thus, in order to read the second file on each of the IBM MEDList tapes, they had to be physically recopied as the first (and only) file on separate blank tapes and then read into the CDC system. Also, they had to be converted into CDC-readable record format using the RCOPY utility.

The computer programs that extracted the sets of census tracts for the Geographical/Demographic files were designed to sort through the master tapes and then to reformat the data into VM-acceptable arrangements. In particular, this involved picking out the relevant data from a format in which they were represented as degrees and fractions of a degree into integer degrees, minutes, seconds (DDDMMSS) format. The conversion program, ICON, and a sample sort program for the New York area, CENSRCH, are presented as Figures 4-7 and 4-8.

E. USAGE OF THE FILES

These files are accessible either by referencing their names in a VM submission jobstream or by referencing their four-digit codes in a UIM-assisted VM run.

The VM will read in a selected file as it stands, sequentially assign cell numbers to each cell-tract ID, and then compute the relative distance in an x-y Cartesian plane from the selected spill site. These data that are printed are in the Geographical Data section of the VM results printout. It is important for the user to keep in mind that all subsequent cell number references are to the VM-assigned sequential cell numbers and not to the cell ID's that appear on the Geographical file maps. To track back a cell, the user must refer back to the aforementioned Geographical Data Table to get the correspondences.

Briefly, to use these files in a VM simulation through execution of the UIM, the user prepares a data file as he/she normally would through the UIM, using the Geographical file maps to produce the appropriate code and to aid in selection of a reasonable spill site. The latitude and longitude "20-second" criterion must be kept in mind in choosing a spill site. After a successful VM run, the user then refers to the Geographical

```
      PROGRAM ICON(INPUT,OUTPUT,TAPE18,TAPE30)
      INTEGER C,B,D,DEG
      DIMENSION M(27),DEG(2),IDEG(2),IMIN(2),ISEC(2)
   10 READ (30,50) C,B,DEG(1),DEG(2),D,II,J,K,(M(L),L=1,27)
      IF (EOF(30) 40,30
   30 DO 35 I=1,2
      IDEG(I) = DEG(I)/10000
      IMIN(I) = (DEG(I)/10000-DEG(I))*60
      ISEC(I) = ((DEG(I)/10000-IDEG(I))*60-IMIN(I))*60
   35 CONTINUE
      WRITE (18,60) C,B,IDEG(1),IMIN(1),ISEC(1),IDEG(2),IMIN(2),
     1ISEC(2),D,II,J,K,(M(L),L=1,27)
      GO TO 10
   40 STOP
   50 FORMAT (A4,1X,A3,2I8,4X,I6,6X,A3,I5,A5,27A1)
   60 FORMAT (A4,".",A3,2(I4,2I2),4X,I6,6X,A3,I5,A5,27A1)
      END
```

FIGURE 4-7

ICON, Program To Convert Latitude and Longitude Formats

```
      PROGRAM CENSRCH(INPUT,OUTPUT,TAPE6=OUTPUT,TAPE10=/132,TAPE15)
      INTEGER POP,HOUSE,FIFTY,AVAL,AZ,BZ
      DIMENSION AZ(26),A(11)
      DATA AZ/26*1H0/,BZ/1H1/,AVAL/5H00600/
      DATA FIFTY/3H050/
      REWIND 10
      CALL PFSUB(6HDEFINE,6HTAPE15,6HTAPE15,0,0,0,0,UCW,ES,ERROR)
   10 READ (10,50) (A(J),J=1,11),HOUSE,POP,LONG,LAT
      IF (EOF(10)) 40,15
   15 IF (IABS(LAT-405236).LE.1159)GOTO 20
      GO TO 10
   20 IF (IABS(LONG-740000).LE.0697)GOTO 30
      GO TO 10
   30 C=A(7)
      B=A(8)
      WRITE (15,60) C,B,LAT,LONG,POP,FIFTY,HOUSE,AVAL,(AZ(K),K=1,26),BZ
      I=I+1
      GO TO 10
   40 CONTINUE
      WRITE (6,70) I
   70 FORMAT (10X,"I=",I3,"CELLS IN THIS FILE.")
   60 FORMAT (2A4,2I8,4X,I6,6X,A3,I5,A5,26A1,A1)
   50 FORMAT (2A2,A3,A7,7X,A5,4X,A4,42X,A4,A3,2A4,A2,I7,I8,2I10)
      STOP
      END
/EOR
/EOF
```

FIGURE 4-8

CENSRCH, Program To Sort Through
the New York/New Jersey Census File

Data Table in the printout to make the conversion between the cell numbers identified in the simulation to be affected (or not affected) by the spill of hazardous cargo and the cell ID's (tract codes) listed on the appropriate map. Not all of the cells listed in the Geographical files will be found on any one map, because some are resolved down to enumeration districts and block groups that are too small in one area to be noted on the maps; in this case, the user must refer to the integer part of the ID to locate the area of concern.

Chapter 5

SPILL SIMULATIONS

A. *OBJECTIVES*

Using the UIM/VM system, spill simulations were performed for a number of chemical cargoes selected by the USCG. The objectives of the simulations were threefold:

- To test and check out the utility and effectiveness of the UIM using untrained operating personnel.
- To validate the UIM/VM system for specific chemicals of interest to the USCG.
- To determine the relative hazard ranking of the chemicals selected for simulation.

B. *APPROACH*

Initially, 27 chemicals were selected as candidates for simulation. The selection was based on their hazard potential as estimated by their chemical properties (chiefly toxicity or flammability) and their shipment characteristics. The various properties of these chemicals needed for the UIM, including the probit coefficients for the toxic chemicals, were developed and inserted in the UIM as discussed in Chapter 2. Then from this list of 27 candidate chemicals, USCG personnel selected 15 chemicals for spill simulation.

Since one of the objectives of the spill simulations was to perform a hazard ranking of the chemicals based on the VM results, canonical spill scenarios were devised which all 15 chemicals could be subjected to. Three standard scenarios were developed, and simulations were run for all 15 chemicals for each of the scenarios.

The simulations were run using the UIM and, for two of the three scenarios, the simulations were performed by personnel with no prior computer experience. These simulations provided proof testing of the utility of the UIM operational manual as well as that of the UIM itself.

The results of the simulations were analyzed in three ways. First, they were examined from the standpoint of UIM effectiveness and utility, with particular attention given to the comments and recommendations of the novice users. Based on recommendations produced by this analysis, appropriate modifications were made to the UIM to improve its ease of use and value. Secondly, the simulation results were examined from the standpoint of compatibility of the UIM with the VM and validity of the VM results. Any inconsistencies or errors found in the VM program as a result of this analysis were corrected and the affected simulations were rerun. Lastly,

the simulation results were analyzed for the purpose of ranking the 15 chemicals according to their casualty-producing potential. Based on a careful scrutiny of the results for all three scenarios, a hazard ranking of the chemicals was produced.

C. *CHEMICALS SELECTED FOR SIMULATION*

Table 5-1 presents the hazard properties of the chemicals selected as candidates for spill simulation. The table gives the type of hazard (flammable or toxic), the lower flammable limit or threshold limit value,* the fire hazard rating given by Sax,** and the toxic hazard rating given by USCG-388.***

Fifteen chemicals were selected for spill simulation from the list of candidate chemicals. The selection was made by USCG personnel based on their interest in particular chemical cargoes. Table 5-2 lists the 15 chemicals and enumerates for each the type of hazard to be simulated and the cargo characteristics, including tank capacity, cargo temperature, and cargo pressure. The tank capacity represents the maximum size of a single tank that is customarily used for that chemical in U.S. marine transportation.

D. *SCENARIO CHARACTERISTICS*

The spill locations and the wind directions specified for the three canonical spill scenarios at Perth Amboy, Coney Island, and Los Angeles are depicted in Figures 5-1, 5-2, and 5-3, respectively. Also noted are the assumed water and air temperatures.

The spill for each scenario was assumed to be caused by a 2-meter-diameter rupture in the cargo tank just above the waterline. The rupture characteristics and tank position with respect to the waterline are depicted in Figure 5-4. The actual amount spilled was computed by the VM (Model A) and was dependent on the size of the tank which was, in general, different for each chemical. Since tanks were assumed to be situated for the most part above the waterline, almost the entire content of each tank was spilled and the computed amount turned out to be roughly 98% of the tank capacity.

---

*In parts per million as adopted by the American Conference of Government Industrial Hygienists.

**Sax, N. Irving, *Dangerous Properties of Industrial Materials*, 5th edit., Van Nostrand Reinhold Company, 1979.

***U.S. Coast Guard, USCG-388, *Chemical Data Guide for Bulk Shipment by Water*.

TABLE 5-1

Hazard Parameters of Chemicals Considered for Spill Simulation

CHEMICAL NAME	CODE	TYPE OF HAZARD	LOWER FLAMMABLE LIMIT (%)	THRESHOLD LIMIT VALUE (ppm)	HAZARD RATING	
					FIRE	TOXIC
Acetaldehyde	AAD	F,T	4.0	200	Dangerous	Some hazard
Acrolein	ARL	F,T	2.8	0.1	Dangerous	Severe hazard
Acrylonitrile	ACN	F,T	3.0	20	Dangerous	Moderate hazard
Ammonia (anhydrous)	AMA	F,T	16	25	Low	Some hazard
Butane	BUT	F	1.9	3700	Very dangerous	Negligible
Butylene	BTN	F,T	1.6	--	Very dangerous	Negligible
Carbon Tetrachloride	CRT	T	NA	10	Nonflammable	Severe hazard
Chlorine	CLX	T	NA	1	Nonflammable	Severe hazard
Dimethylamine	DMA	F,T	2.8	10	Very dangerous	Some hazard
Ethyl Ether	EET	F,T	1.85	400	Very dangerous	Some hazard
Hydrogen Chloride	HDC	T	NA	5	Nonflammable	Moderate hazard
Hydrogen Cyanide	HCN	F,T	5.6	10	Very dangerous	Severe hazard
Hydrogen Fluoride	HFX	T	NA	3	Nonflammable	Severe hazard
Hydrogen Sulfide	HDS	F	4	10	Very dangerous	Some hazard
Liquefied Natural Gas	LNG	F	5.3	--	Dangerous	Negligible
Liquefied Petroleum Gas	LPG	F	2.2	1000	Moderate	Negligible
Methyl Bromide	MTB	F,T	10	4	Moderate	Severe hazard
Methyl Chloride	MTC	F,T	8.1	100	Highly dangerous	Some hazard
Octane	OAN	F	1.0	300	Dangerous	Negligible
Pentane	PTA	F	1.4	500	Highly dangerous	Negligible
Phosgene	PHG	T	NA	0.1	Nonflammable	Severe hazard
Propane	PRP	F	2.2	1000	Highly dangerous	Negligible
Propylene	PRP	F	2.0	400	Highly dangerous	Minimal hazard
Propylene Oxide	POX	F,T	2.1	100	Highly dangerous	Some hazard
Sulfur Dioxide	SFO	T	NA	5	Nonflammable	Severe hazard
Toluene	TOL	F,T	1.27	100	Slight	Some hazard
Vinyl Chloride	VCM	F,T	3.6	1	Dangerous	Some hazard

TABLE 5-2

Chemical Cargoes Selected for Spill Simulation

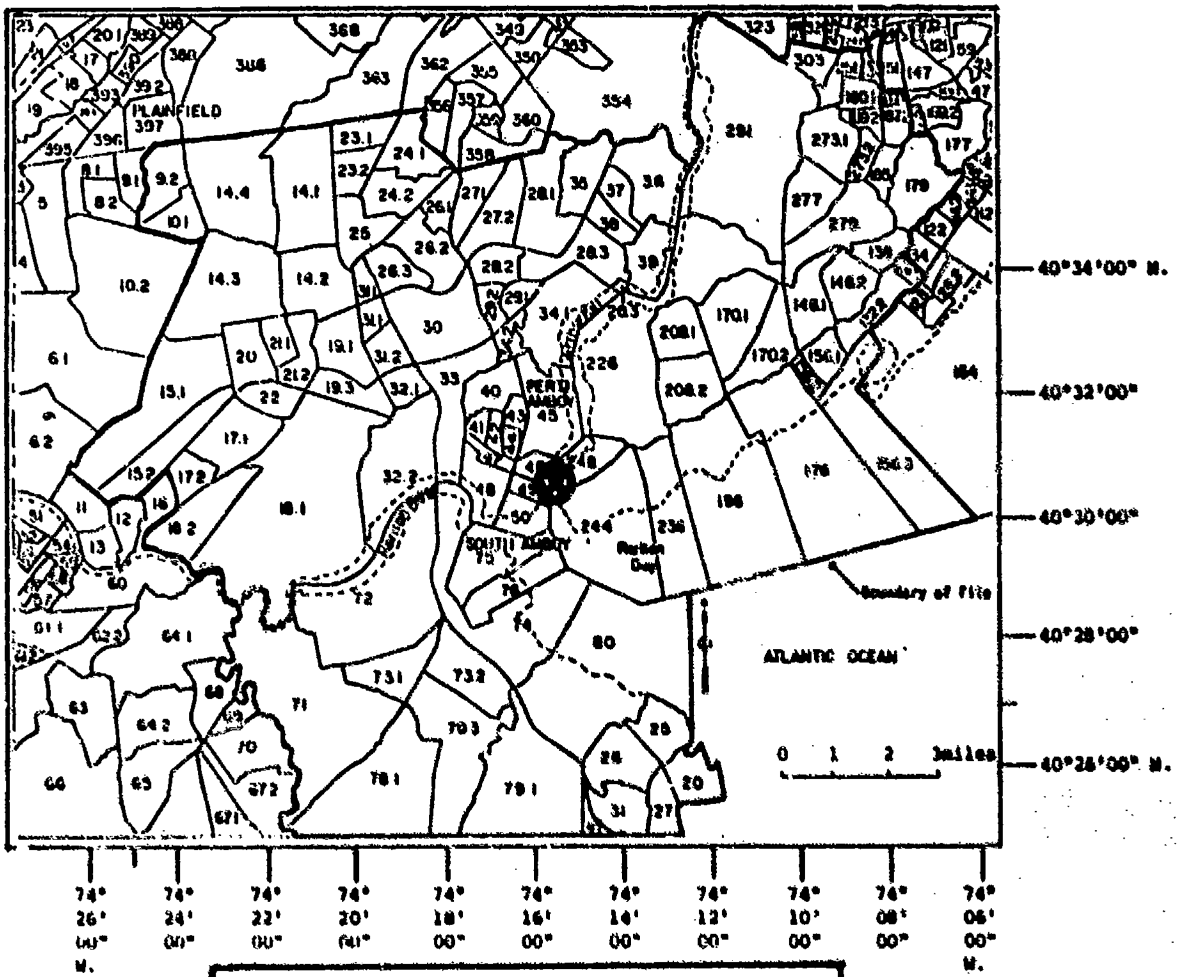
CHEMICAL NAME	CODE	TANK CAPACITY (m^3)	TANK HEIGHT (m)	CARGO PRESSURE[a] (atm)	CARGO TEMPERATURE[b] (°C)	HAZARD[c]
Acetaldehyde	AAD	3,000	15	1 (C)	Ambient	F
Acrylonitrile	ACN	3,000	15	1 (C)	Ambient	T
Ammonia (Anhydrous)	AMA	10,000	20	1 (V)	-33	T
Chlorine	CLX	182	7	1 (V)	-33	T
Dimethylamine	DMA	3,000[d]	15	2.5 (C)	Ambient	F
Ethyl ether	EET	3,000[d]	15	1 (C)	Ambient	F
LNG	LNG	25,000	22	1 (V)	-161	F
LPG	LPG	10,000	20	1 (V)	-40	F
Methyl bromide	MTB	3,000	15	1 (C)	4	[illegible]
Methyl chloride	MTC	3,000[d]	17	1 (V)	-24	F
Octane	OAN	4,000	17	1 (C)	Ambient	F
Pentane	PTA	4,000	17	1 (C)	Ambient	F
Propylene oxide	POX	3,000	15	1 (C)	Ambient	T,F
Toluene	TOL	4,000	17	1 (C)	Ambient	T
Vinyl chloride	VCM	6,000	17	1 (V)	-14	F

[a] (C) = closed tank; (V) = vented tank

[b] Ambient = sea temperature

[c] F = flash fire; T = toxic

[d] Double tank capacity (6,000 m^3) was also simulated for these three cases.

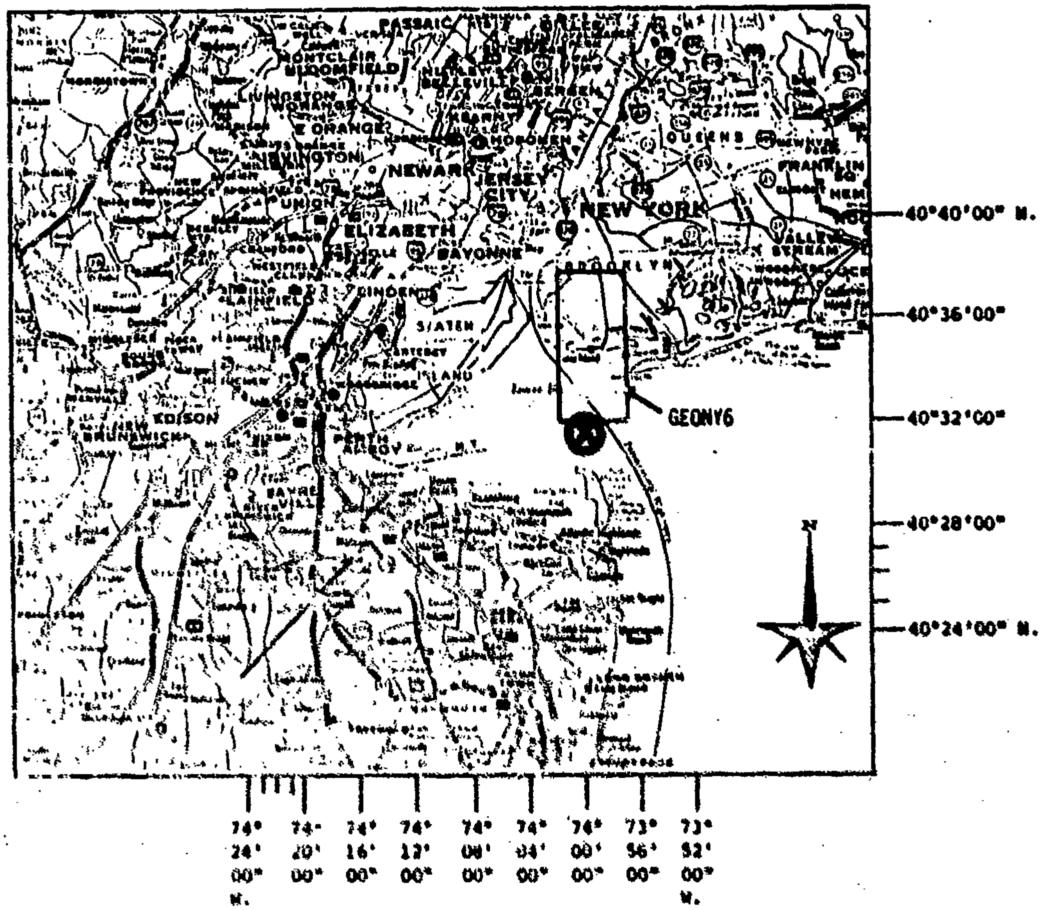


: SPILL SITE

Coordinates of spill site: 40°30'40" N.
74°15'35" W.

Wind vector: 325°, 2 m/s
Surface sea temperature: 22°C
Average air temperature: 28°C

FIGURE 5-1. Scenario Map for the Perth Amboy Spill Simulations



●: SPILL SITE

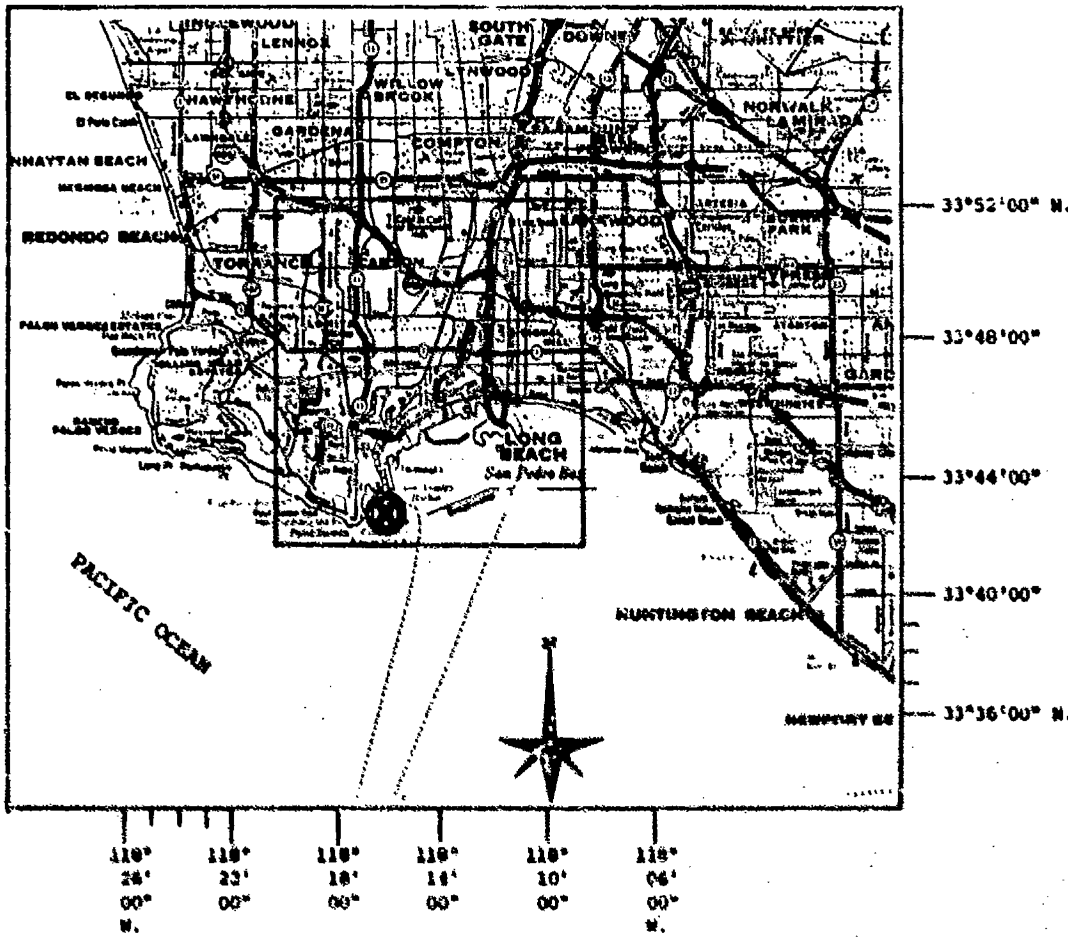
Coordinates of spill site: 40°31'25" N.
74°00'00" W.

Wind vector: 5°, 4 m/s

Surface sea temperature: 22°C

Average air temperature: 28°C

FIGURE 5-2. Scenario Map for the Coney Island Spill Simulations



: SPILL SITE

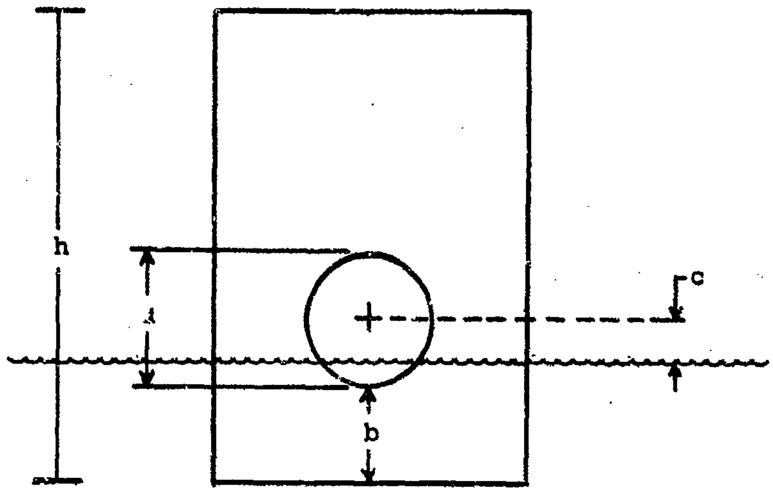
Coordinates of spill site: 33°42'34" N.
118°16'19" W.

Wind vector: 0°, 4 m/s

Surface sea temperature: 20°C

Average air temperature: 24°C

FIGURE 5-3. Scenario Map for the Los Angeles Spill Simulations



h = height of tank
d = diameter of rupture
b = height of rupture above bottom of tank
c = height of center line above water surface

For simulation scenarios:

d = 2 meters
b = 0
c = 1 meter

FIGURE 5-4. Rupture Characteristics

From the standpoint of hazard ranking, the use of spill sizes which are dependent on the maximum tank capacities for the chemicals is considered to be a valid analytical technique even though it results in different spill sizes for the different chemicals. The magnitude of the hazard is to a large extent dependent upon the amount spilled, which in turn is dependent on the size of the tank. Thus, the size of the tank should play a part in the ranking of the hazards, which it does in the method of analysis used here.

E. *CHECKOUT OF UIM/VM SYSTEM AND SPILL SIMULATION PRODUCTION*

1. *Initial System Test*

To check out the UIM/VM system, spill simulations were run first for the Perth Amboy scenario for all 15 chemicals. VM results were carefully examined for errors and inconsistencies. This exercise yielded several logic errors that needed to be corrected. Also, several cosmetic improvements were made to the VM output tables to enhance their ease of use. Once these modifications were made, the spill simulations were run for all three scenarios (including a rerun of the simulations for Perth Amboy).

2. *Production Runs*

The production runs of the spill simulations were performed for the most part by non-computer-oriented personnel. Two methods were used to train the operators. For the operators who had some prior knowledge of the VM (but no computer experience), training was provided in a short orientation session of about one-half hour in duration. Then, during their first UIM session an experienced operator stood by to assist the novice operators when necessary. After the UIM initial session, the novice was generally on his own.

The second type of training was attempted for those personnel who were totally unfamiliar with the VM. These persons were asked to study the UIM manual for several hours. Then the trainee was given a spill scenario to run and, as before, the experienced operator was available to assist the novice during his first UIM session.

Both methods of training the novice operators were found to be effective. After the first session, the first-time users could set up and run VM simulations completely on their own. The only assistance needed was for unusual computer system problems or for interpreting the VM output.

3. *VM Modifications*

As previously discussed, the initial checkout simulations at Perth Amboy identified several VM program errors and inefficiencies. Likewise, the production runs resulted in several recommendations for simplifying and clarifying the VM output tables. The modifications made to the VM program as a result of these findings are described below.

The time-incremented radiation flux tables, which have no utility since the revision of the flash fire model, were removed from the VM output.

An unused variable, field ID 4012, was reactivated as a flag to suppress printout of the ppm concentrations table, since this could be redundant in light of the fact that a concentrations table in units of kg/m^3 is also printed. If the new variable PPMSUP is set to 1, the table is not printed; if set to any other value or not set at all, the table is printed. The kg/m^3 concentrations table is printed regardless of the value of PPMSUP.

In subroutine DOSAGE, the time-concentration product computation routine for toxic chemicals, it was discovered that the interior dosage was being incorrectly computed due to a units error; this has been rectified. Also, a mistyping of the air temperature variable, AIRTEM, leading to a misassignment of zero for this variable in this subroutine has been corrected. Further, if a toxic spill run is requested, the Ignition Output Table will no longer be printed. This has been implemented since in the case of a toxic spill, very few of the entries in this table are applicable, and those that are applicable are of minor importance to the analyst.

In the flash fire subroutine, FLFIRE, it was discovered that the formula used for computing fireball size was incorrect, and has been amended to reflect the change. In particular, the density of the fuel vapor is now being used rather than that of the combustion products. Also in this subroutine, due to an earlier VM change, the value of the secondary fires flag, NSF, was being incorrectly assigned and was causing a fatal FORTRAN error to occur in VMEXEC when no request for secondary fires analysis (3004=0) and ignition occurred. This has been corrected both here and in main routine VMEXEC.

In MODZ, the values for sigma-y and sigma-z at time of ignition were not being printed when the plume submodel was in effect. This led to misleading default values of zero being printed in the Ignition Output Table for these variables. This has been reprogrammed to be consistent with the puff submodel printout format.

In subroutine PATH, a logic error was causing execution of Model F, which determines the amount of time needed to dissolve a water-soluble chemical, to be executed for certain immiscible liquids. This was corrected by deleting the setting of the model number corresponding to F to a non-zero number (6) if such chemicals were being considered.

In the spillage rate determination section of the VM, certain combinations of tank geometry and insulative type were causing floating point overflows in subroutine RLJTC. This only occurred if adiabatic tank conditions (2006=1) were specified, and has been corrected by including impending overflow-sensing lines of code to protect against this condition by flagging for termination of the particular loop sequence where this may occur, and continuance of normal flow.

In Phase II, the blast damage tables were often printed out with many subtables showing no apparant damage for some cells. The threshold level for the selection of blast damage printout or nonprintout has been reset, and very few "zero subtables" are now being observed, thus reducing a potential source of confusion.

Finally, for test purposes, it is now possible to bypass the PATH subroutine and the escape-, spreading-, and evaporation-rate determining subroutines entirely, and to go directly to MODC by setting reactivated field ID 4013, BYP, to 1 in the input file (default is zero). This forces the VM to use the user's input file values for total mass liberated (TMV, 4023) in lieu of the calculated values; and in the case of the plume (continuous spill) submodel, the minimum of either time to effect complete evaporation (TEVAP, 4016) or the value of the first time in the first-specified time sequence* (TLAST, 5050, which is derived from field ID's 6001, 6004 or 6007) for determining the value of Q_B, the source strength item. Therefore, when using this option for a plume simulation (5010=1), the user must specify a value for field ID's 4023, 4016 and either 6001, 6004 Or 6007, or else execution-time errors will occur.

*When specifying the time sequence for a toxic chemical, a time progression should not be used since the VM will select the first time specified in the progression, perform a computation set based on it, and then will directly proceed to Phase II, ignoring any remaining time increments.

F. *SIMULATION RESULTS*

The principal results of the spill simulations for the 15 chemicals at Perth Amboy, Coney Island, and Los Angeles are presented in Table 5-3. Given are the number of deaths, injuries and, in the case of flammable chemical spills, the number of buildings destroyed. The figures for deaths and injuries are the total casualties for both outdoors and indoors personnel. The parenthetical values show the portion of the total occurring indoors. For some of the toxic chemicals, injury probits have not been developed (for lack of data) and, thus, injuries were not computed. Comments are given in the last column of Table 5-3 regarding the nature of the cloud simulated (puff or plume) and the solubility and volatility of the chemical. These comments are useful in explaining and interpreting the results.

For ethyl ether a spill from two tanks was simulated (i.e., 6,000 m^3 rather than 3,000 m^3). A spill from a single tank resulted in zero casualties for ether, but an examination of the results disclosed that the vapor concentrations at the closest cells were very close to the lower flammable limits. Consequently, a double size spill was simulated to provide a means of differentiating between this marginally hazardous chemical and the other zero casualty chemicals which produced downwind concentrations far below hazardous levels.

Acetaldehyde, acrylonitrile, dimethylamine, and propylene oxide produced no damage due to their high solubility. As evident from the following table, only a very small percentage of the spilled material vaporized and the rest went into solution. Due to the small amount of vapor, the highest concentration at the nearest cell was orders of magnitude below the lower flammable limit, as noted for acetaldehyde and propylene oxide.

Chemical	Mass Vaporized (kg)	Mass Vaporized / Mass Spilled (%)	Concentration at Nearest Cell (kg/m^3)	Lower Flammable Limit (kg/m^3)
Acetaldehyde	1,890	0.008	8.2×10^{-6}	7.6×10^{-2}
Acrylonitrile	240	0.010	Not recorded in VM output	Non-flammable
Dimethylamine	401	0.002	-	-
Propylene Oxide	1,300	0.005	5.0×10^{-6}	5.0×10^{-2}

TABLE 5-3. Results of Spill Simulations

CHEMICAL NAME (CODE)	PRINCIPAL HAZARD	TANK SIZE (m^3)	DEATHS			INJURIES			BUILDINGS DESTROYED			REMARKS
			Perth Amboy	Coney Island	Los Angeles	Perth Amboy	Coney Island	Los Angeles	Perth Amboy	Coney Island	Los Angeles	
Acetaldehyde (AAD)	F	3,000	0	0	0	0	0	0	0	0	0	Plume, moderately volatile, soluble
Acrylonitrile (ACN)	T	3,000	0	0	0	--	--	--	NA	NA	NA	Plume, highly volatile, soluble
Ammonia (AMA)	T	10,000	1,845 (916)	0	0	--	--	--	NA	NA	NA	Plume, highly volatile, soluble
Chlorine (CLX)	T	182	9,349 (4,674)	75,038 (21,799)	18,744 (3,169)	3,020 (1,510)	69,274 (44,710)	27,841 (19,418)	NA	NA	NA	Puff, highly volatile, low solubility
Dimethylamine (DMA)	F	3,000	0	0	0	0	0	0	0	0	0	Plume, moderately volatile, soluble
Ethyl Ether (EET)	F	6,000*	188	0	0	342	0	0	372	0	0	Plume, moderately volatile, soluble
Liquef. Nat. Gas (LNG)	F	25,000	1,692	9,557	49	2,903	5,607	510	1,953	9,029	0	Puff, moderately volatile, immiscible
Liquef. Petr. Gas (LPG)	F	10,000	589	7,145	175	965	4,887	427	1,038	8,349	101	Puff, highly volatile, immiscible
Methyl Bromide (MTB)	T	3,000	7,947	1,086	48	--	--	--	NA	NA	NA	Puff, highly volatile, immiscible
Methyl Chloride (MTC)	F	3,000	47	0	0	479	0	0	372	0	0	Plume, highly volatile, immiscible
Octane (OAN)	F	4,000	0	0	0	0	0	0	0	0	0	Plume, low volatility, immiscible
Pentane (PTA)	F	4,000	164	0	0	365	0	0	372	0	0	Plume, moderately volatile, insoluble
Propylene Oxide (POX)	T	3,000	0	0	0	--	--	--	NA	NA	NA	Plume, moderately volatile, soluble
	F	3,000	0	0	0	0	0	0	0	0	0	
Toluene (TOL)	T	4,000	48 (24)	0	0	--	--	--	NA	NA	NA	Plume, low volatility, insoluble
Vinyl Chloride (VCM)	F	6,000	276	0	0	254	0	0	372	0	0	Plume, highly volatile, immiscible

Notes: Perth Amboy: stability class F, closest downwind cell at 0.4 km.
Coney Island: stability class D, closest downwind cell at 5.4 km.
Los Angeles: stability class D, closest downwind cell at 1 km.

Highly volatile: boiling point less than sea temperature (68°F).
Moderately volatile: boiling point between sea temperature and 180°F.
Low volatility: boiling point greater than 180°F.

-- = no injury computations made due to lack of injury probits in VM.
NA = not applicable.
( ) = casualties to personnel indoors.

*Two tanks assumed spilled; simulation for a single tank resulted in no casualties.

The only other chemical that resulted in no damage for all three scenarios was octane. This was due to its relatively low volatility. The data below compares the source strength of octane to the other flammable chemicals which formed a plume of sufficient concentration to ignite at Perth Amboy. The source strength of octane is much less than that of the four chemicals which ignited. Note that the time of evaporation for octane is roughly an order of magnitude greater than the others.

Chemical	Time of Evaporation (min)	Plume Source Strength (kg/sec)	Result at Perth Amboy
Ethyl Ether	33	485	Ignition
Methyl Chloride	27	215	Ignition
Octane	200	52	No ignition
Pentane	25	426	Ignition
Vinyl Chloride	18	342	Ignition

The maximum vapor concentration of octane at the closest cell at Perth Amboy was 3.5×10^{-3} kg/m^3 and the lower flammable limit is 4.9×10^{-2}, thus no ignition occurred.

Six chemicals produced casualties at Perth Amboy, but not at the other two spill sites. These were the four flammable chemicals that ignited in the above table plus the two toxic chemicals, toluene and ammonia. All six of these chemicals exhibited evaporation times more appropriate to plume formation than puff. Absence of casualties at Coney Island and Los Angeles was due to the greater distances between spill site and nearest downwind cell and to the less stable atmospheric conditions that existed at these sites compared to Perth Amboy. The nearest cell distances at Coney Island and Los Angeles were 5.4 km and 1 km, respectively, compared to 0.4 km at Perth Amboy. Thus, because of the near-in spill site and the very stable air assumed at Perth Amboy, the concentrations in the plumes were sufficiently high to cause damage at the near-in cells. But at Coney Island and Los Angeles, the lowering of the stability and the increase in distance were sufficient to reduce the plume concentrations to below hazardous levels. Thus, the six chemicals can be considered to be marginally hazardous; that is, hazardous only under a fairly narrow set of conditions.

Four chemicals resulted in casualties at all three spill sites. These were chlorine, LNG, LPG, and methyl bromide. All four of these chemicals were both highly volatile and immiscible, and the evaporation times were sufficiently low to cause the vapor cloud to exhibit puff-like behavior with concomitant high concentrations. The table below shows the evaporation times computed by the VM for each of the four chemicals.

Chemical	Evaporation Time (min)	Boiling Point (°F)
Chlorine	0.3	-29
LNG	4.1	-258
LPG	6.5	-40
Methyl Bromide	0.6	+40

Chlorine's evaporation time was shorter than the others, due principally to the relatively small size of spill. Because liquid methyl bromide is heavier than seawater, the VM selected a different vapor formation model for methyl bromide than for the others: the sinking and boiling model rather than the floating cryogen model. The sinking and boiling model simulated very rapid evaporation, presumably enhanced by boiling turbulence and the concomitant rapid heat transfer.

Because of the rapid cloud formation, the vapor concentrations of chlorine, LNG, LPG, and methyl bromide were sufficiently high to remain hazardous for long distances under class D stabilities. For chlorine, LNG and LPG, the casualties were greater at Coney Island than at Perth Amboy or Los Angeles because of two effects:

- higher population density
- larger vapor cloud area due to lower stability and greater distance to vulnerable resources.

The amounts spilled and the hazard properties of these three chemicals were sufficient to cause the chemicals to remain extremely hazardous even with the dilution resulting from larger distances and lowering stabilities.

In the case of methyl bromide, the dilution due to greater distance and less stability was sufficient to greatly reduce the casualties at Coney Island and Los Angeles, relative to the casualties at Perth Amboy.

For LNG and LPG spills, the vapor clouds were ignited by the geographic cells first encountered, when most of the cloud was over the water and only a small portion intersected the land. This had the effect

of minimizing the casualties, especially at Los Angeles where the geographical cells that bordered the harbor were not heavily populated. The reason the LNG spill resulted in less fatalities than the LPG spill at Los Angeles was due to the greater penetration of the smaller LPG vapor cloud before ignition. This is purely a chance result having little bearing on relative hazard potential of the two chemicals.

G. *HAZARD RANKING*

The results of the simulations have been analyzed for the purpose of ranking the chemicals according to their relative hazard potential. The principal measure of hazard potential used in the analysis is the number of fatalities, since it is the most consistent and accurate measure produced by the VM. Some consideration is given to number of injuries and buildings destroyed; however, injuries are not computed for some toxic chemicals (insufficient medical data for estimating injuries) and structural damage of course is not computed for toxic chemicals. Thus, injuries and structural damage are useful only for ranking between chemicals for which the calculations were made.

A second hazard factor used in the hazard ranking is specific lethality. Specific lethality is defined as the deaths per cubic meter of material spilled. This hazard measure normalizes the effects of all chemicals for a given quantity of chemical spilled and provides a measure of the relative hazards of the chemicals for the same size of spill.

Table 5-4 is a tabulation of the hazard factors (total deaths and specific lethality) derived from the VM simulations for the 15 chemicals and the three scenarios. The chemicals are grouped according to solubility and volatility. The most hazardous category is presented at the top of the list (insoluble and highly volatile) and the least hazardous at the bottom (soluble, low volatility).

Based on an examination of the hazard factors, the 15 chemicals are grouped into four hazard categories and ranked according to hazard potential. This categorization and ranking is presented in Table 5-5. Chlorine is by far the most hazardous chemical. It not only produced the most casualties at all three spill sites but accomplished this with a relatively small spill, thereby exhibiting a very large specific lethality compared to the other chemicals.

LNG, LPG, and methyl bromide were ranked in the next most hazardous category. They produced significant casualties for all three spill scenarios. Although LNG generally produced more casualties and structural damage than LPG, it did it with a much larger spill (25,000 vs. 10,000 m^3). At Perth Amboy the specific lethalities were approximately equal for LNG and LPG, and at Coney Island and Los Angeles the specific lethality for LPG was greater than that for LNG. Because each is ranked higher than the other for one of the two hazard factors, it was felt that a differentiation between the hazard potential of the two chemicals could not be made and they were ranked equally.

TABLE 5-4. Hazard Factors Derived from Simulations

CHEMICAL CHARACTERISTICS		CHEMICAL NAME	HAZARD TYPE	SPILL SIZE (m^3)	PERTH AMBOY		CONEY ISLAND		LOS ANGELES	
Solubility	Volatility				Total Deaths	Specific Lethality[a]	Total Deaths	Specific Lethality[a]	Total Deaths	Specific Lethality[a]
Insoluble	High	Chlorine	T	182	9,350	51.4	75,040	412	18,740	103
		LNG	F	25,000	1,690	0.07	9,560	0.38	49	0.002
		LPG	F	10,000	590	0.06	7,640	0.76	175	0.02
		Methyl Bromide	T	3,000	7,950	2.65	1,090	0.36	48	0.02
		Methyl Chloride	F	3,000	47	0.016	0	0	0	0
		Vinyl Chloride	F	6,000	276	0.05	0	0	0	0
	Moderate	Ethyl Ether	F	6,000*	188	0.03	0	0	0	0
		Pentane	F	4,000	164	0.04	0	0	0	0
	Low	Octane	F	4,000	0	0	0	0	0	0
		Toluene	T	4,000	48	0.01	0	0	0	0
Soluble	High	Ammonia	T	10,000	1,845	0.2	0	0	0	0
		Dimethylamine	F	3,000	0	0	0	0	0	0
	Moderate to Low	Acetaldehyde	F	3,000	0	0	0	0	0	0
		Acrylonitrile	T	3,000	0	0	0	0	0	0
		Propylene Oxide	T	3,000	0	0	0	0	0	0

[a]Specific Lethality = deaths divided by spill size (fatalities per cubic meter).

*Double tank spill.

TABLE 5-5. Hazard Ranking

HAZARD CATEGORY	CHEMICAL	TYPE OF HAZARD	HAZARD RANK	MAXIMUM FATALITIES	MAXIMUM SPECIFIC LETHALITY	REMARKS
MOST HAZARDOUS (thousands of fatalities at all three scenarios)	Chlorine	T	1	75,040	412	
VERY HAZARDOUS (appreciable deaths under a variety of conditions)	LNG	F	2	9,560	0.38	
	LPG	F	2	7,640	0.76	
	Methyl Bromide	T	2	7,950	2.65	
HAZARDOUS (fatalities only under a narrow range of conditions)	Ammonia	T	3	1,845	0.2	
	Vinyl Chloride	F	4	276	0.05	
	Pentane	F	4	164	0.04	
	Methyl Chloride	F	5	47	0.016	
	Toluene	T	5	48	0.01	
	Ethyl Ether*	F	6	188	0.03	No fatalities with single tank spill
RELATIVELY NONHAZARDOUS	Octane	F	7	0	0	Very low volatility
	Dimethylamine	F	7	0	0	Soluble
	Acetaldehyde	F	7	0	0	Soluble
	Acrylonitrile	T	7	0	0	Soluble
	Propylene Oxide	T/F	7	0	0	Soluble

*Double tank.

Methyl bromide was also given the same ranking as LNG and LPG. It produced appreciably more casualties at Perth Amboy than did LNG or LPG, but the reverse was true for Coney Island. Although the specific lethality was about four times greater for methyl bromide at Perth Amboy than that of LNG and LPG, it was comparable at the other two sites. Considering the fact that LNG and LPG hazards were not maximized,* the larger specific lethality for methyl bromide was not considered significant and methyl bromide was given the same hazard potential ranking as LNG and LPG.

All of the chemicals that resulted in casualties only at Perth Amboy were placed in the next hazard category. Of these, ammonia was clearly the most hazardous due both to the large number of casualties and to the larger specific lethality. Vinyl chloride and pentane, with approximately the same specific lethality and comparable total deaths, were ranked next. Then followed methyl choride and toluene, whose hazard factors were quite comparable. The last of the chemicals ranked as "hazardous" was ether which did not produce any casualties for a single tank spill, but did for a double tank.

The five chemicals that did not cause casualties for any of the scenarios were ranked as relatively nonhazardous. Since the Perth Amboy scenario was a rather extreme scenario in terms of population proximity and atmospheric stability, the lack of casualties at Perth Amboy indicates that these chemicals will probably not result in acute damage under most large-spill conditions.

In sum, the 15 chemicals were ranked in four major hazard categories and in seven subcategories. The only chemicals that were ranked in the most hazardous or very hazardous categories were insoluble, highly volatile chemicals. The only soluble chemical to be ranked as hazardous was ammonia, for which a large spill was simulated. All other hazardous chemicals were insoluble and moderately to highly volatile. All the relatively nonhazardous chemicals were either insoluble or involatile.

A final comment is made regarding the hazards of toxic versus flammable chemicals. The toxic chemicals in general exhibited the greatest hazard potential (for the insoluble, highly volatile chemicals). The reason for this is that the toxic puff or plume made a long swath through the populated area and many people within this area became fatalities. In the case of the flammable chemicals, only those exposed people in the vicinity of the vapor cloud at the time of ignition became casualties. When ignition occurred, it occurred soon after the vapor cloud reached the shore, and in general only a portion of the cloud was over land at the time. The casualties for LNG and LPG might have been appreciably greater if ignition had been delayed until the vapor cloud covered a more populated region, especially for the Los Angeles simulations where the cells near the shore were relatively unpopulated. However, the one-shot casualty-producing characteristics of the flammable vapor cloud versus the

*Delayed ignition could have produced greater casualties for LNG and LPG.

continuous casualty-producing effects of the toxic vapor cloud, together with the early ignition likelihood of flammable clouds, make the highly flammable chemicals less hazardous than the highly toxic ones. This conclusion is based on direct casualties only, and does not consider the fire damage to structures or the casualties that might occur if a fire storm occurred as a result of widespread ignition. Also, it does not consider evasive tactics which could reduce the toxic casualties significantly at far-field downwind distances. These latter considerations are functions of the effectiveness of civil emergency plans, time of day and day of week, local fire protection availability, and many other variables which are difficult to quantify.

Chapter 6

FILES AND TAPES CREATED UNDER THIS CONTRACT

Two new chemical properties tapes were created in SCOPE-internal (SI) format, in seven-track, 800 BPI, ANSI-labelled format. Their visual serial numbers (VSN's) are S3216 and S26506=KW4942, and they replace S3984 which wore out.

The updated VM was recompiled using the optimizing FORTRAN processer. Both the source code and Phase 1, Phase 2 object modules were written onto a new tape, OS1828. Also recorded on this tape was the entire Chemical Properties file, plus the Default and DPI Values files, to conserve system resources demand. The new tape is a public-access, nine-track, 1600 BPI, labelled tape, VSN=OS1828. A request card for this tape would look as follows:

REQUEST,TAPE,NT,PE,CT=PU,ID=USCG,VSN=OS1828.

The first file on this tape is the updated VM source code (VMSYM or OLDPL); then, in order of appearance, comes the entire Chemical Properties file, the Default Values file, the DPI Table file, the Phase 1 object module, and the Phase 2 object module.

As a backup to this tape, a new VM file set has been catalogued on SCOPE as Cycle 15. Cycle 15 stores USCGVUIMODLGO, which contains both updated object modules (ID=USCG) and NEWVMSYM, which contains the updated VM source code (ID=USCG). Public-access tape OS7073*has been created to complement these files; it contains, in the following order, the entire Chemical Properties file, the Default Values file, and the DPI Table file. Jobstream DISPVM (Figure 3-1 in Chapter 3) illustrates the tandem usage of OS7073 and USCGVUIMODLGO. The total disk storage required for Cycle 15 is 659 SDB's (standard data blocks).** Standard VM run jobstream RUNUIM2 (formerly, CHEAPVM) illustrates the usage of tape OS1828; it is listed in Chapter 2 as Figure 2-6. Note that in both jobstreams VM output is directed toward the printers at the Eastern Cybernet Center, 1151 Seven Locks Road, Rockville, Maryland 20854.

Tables 6-1 and 6-2 list the current SCOPE-resident tapes and files, respectively, available under Coast Guard account S7205.

---

*Nine-track, 1600 BPI, ANSI-labelled.

**There are 1280 characters (6-bit) per SDB.

TABLE 6-1

USCG: SCOPE Tapes Audit

USER TAPE AUDIT 06/25/79 16.21.38. PAGE NO. 1
AUDITRS.

VSN	LFN	DATE RESERVED	DATE LAST ACCESS	NO. OF ACCESSES	-----FILE CHARACTERISTICS-----	----FILE STATUS----	INITIATOR COMMENTS
S26506	KW4942	030779	060779	306	MT, HY, U/Z,	PR,	KRNICH
ACCOUNT =	S7205	FID =			LAST WRITE = 030779	JOBNAME = TRE-ADD	
S3.16	TAPE	030879	040279	80	MT, HY, U/Z,	PR,	
ACCOUNT =	S7205WRI	FID =			LAST WRITE = 030879	JOBNAME = LAK0003	
S5200	BAKTAPE	080977	062279	709	MT, HY, U/Z,	PU, XR R,	
ACCOUNT =	S7205WRI	FID =	USCGVULMCD		LAST WRITE = 080977	JOBNAME = VCNRUG0	
S8562	BAKTAPE	062878	060579	287	MT, HY, U/Z,	PU, XR	
ACCOUNT =	S7205WRI	FID =	USCGVULMCD		LAST WRITE = 062878	JOBNAME = VCEEUQT	
S13346	BAKTAPE	031279	031279	2	MT, HY, U/Z,	PU, XR X,	
ACCOUNT =	S7205WRI	FID =	USCGVULMCD		LAST WRITE = 031279	JOBNAME = VAWM[illegible]Y	
S25719	BAKTAPE	060578	122778	53	MT, HY, U/Z,	PU, XR X,	
ACCOUNT =	S7205WRI	FID =	USCGVULMCD		LAST WRITE = 060578	JOBNAME = VC00USW	
S3984	SYS-ADD	040877	021779	261	MT, HY, U/Z,	PR, X, R,	TSAO
ACCOUNT =	S7205WRI	FID =			LAST WRITE = 040877	JOBNAME = TRE-ADD	
S4179	BAKTAPE	060877	080877	134	MT, HY, U/Z,	PU, XR X, L,	
ACCOUNT =	S7205WRI	FID =	USCGVULMCD		LAST WRITE = 060877	JOBNAME = VDCDUC1	
S1828	VMTAPE	062279	062379	3	NT, PE, U/Z,	PU	ARTICOLA
ACCOUNT =	S7205WRT*ECI*	FID =	USCGVULMOD		LAST WRITE = 062279	JOBNAME = LDIFAEB	

TABLE 6-2

USCG: SCOPE Files Audit

AUDIT OF 6000 PERMANENT FILES FULL TIME 16.21.36 06/25/79

SETNAME=SYSTEM:

OWNER	PERMANENT FILE NAME	CYCLE	ACCOUNT	UNIT	SDBS	CREATION	EXPIRATION
SUBD	NO. ATTACHES	NO. ALTERS/REWRITES		FLAGS	RBS	VSN-1	VSN-2
USCG	USCGVULMODLGO	15	S7205MRT	0065	298	06/22/79	03/17/82
26	6	0			11	PFD104	******
USCG	NEWVMSYM	15	S7205MRT	0087	361	06/22/79	03/17/82
26	1	0			13	PFD108	******

Appendix A

DESCRIPTION OF THE VULNERABILITY MODEL

Appendix A

DESCRIPTION OF THE VULNERABILITY MODEL

The Vulnerability Model (VM) is a computer simulation which assesses the consequences of hazardous materials spills. When the user specifies the:

- characteristics of the cargo (e.g., chemical composition, size of tank, temperature of cargo),
- size and location of the rupture,
- characteristics of the spill environment (e.g., marine characteristics and weather conditions),
- geographical location of the spill, and
- location and characteristics of the vulnerable resources (people and property) in the vicinity of the spill;

the VM will compute the:

- size and characteristics of the spill,
- disposition of the hazardous material (e.g., mixing, sinking, dilution, vaporization, diffusion, dispersion),
- concentrations and hazardous effects of spilled material as a function of position and time (e.g., toxic concentration and dose, thermal intensity and dose, overpressure), and
- number of people killed and injured and amount and value of property damaged.

The VM simulates two basic types of hazardous chemicals: *toxic* and *flammable*. For toxic chemical spills, the VM simulates the development of the spill, the vaporization of the chemical and the formation of a toxic cloud or plume, the movement and dispersion of the cloud, and the acute toxic damage (deaths and injuries) occurring to people residing in the path of the cloud.

For flammable chemicals, the VM computes fire damage to people and property resulting from three types of fire hazards: pool burning, fireball, and flash fire. *Pool burning* occurs when an immiscible flammable liquid is spilled and catches on fire at the spill site while it is still in the form of a floating pool of liquid.

A *fireball* occurs when a pressurized gas or highly volatile liquid is ignited as it escapes, bursting the tank and generating a highly combustible mixture of material and air which burns very rapidly and forms a fireball. The fireball hazard is common for incidents involving propane.

Flash fire occurs for volatile chemical spills which do not catch fire at the spill site (due to lack of an ignition source) but form flammable vapor clouds which are blown downwind and are ignited at some distance from the spill site. The flash fire hazard can be the most serious, because it involves the transport of the hazardous material from the spill site to downwind areas that can be much more populated than the spill site. If, at the time of ignition, all of the spilled liquid has not been vaporized, then pool burning occurs in addition to flash fire. Also, the possibility exists that under certain conditions the highly combustible vapor cloud can explode rather than burn. Hence, the VM simulates the explosion of the vapor cloud in addition to flash fire and computes the explosion damage to people and property as well as flash fire damage. The user is cautioned that in all cases involving unconfined flammable vapor clouds, flash fire is much more likely to occur than explosion. However, explosion is included as a worst-case consideration, even though it is recognized to be a remote possibility in most spill situations.

The VM is designed to simulate the consequences of hazardous materials spills at specific ports, harbors, or other marine locations. To do this, the user must specify the location and characteristics of the vulnerable resources in the vicinity of the spill site. This is accomplished by means of a Geographical/Demographical file which divides the area of interest into cells and gives the location, number of people, and number and value of buildings for each cell. In simulating damage, the VM computes the damaging effects such as toxic dose or radiation dose occurring at each cell; converts this to the fraction of people and buildings damaged at each cell, multiplies by the number of people and buildings that exist in each cell; then adds up the damage for all cells.

The VM simulates spills in confined waters as well as open waters. It also considers the effects of tidal or river flows if specified by the user. The VM does not, however, simulate the effects of topography on vapor cloud dispersion; i.e., it assumes that the land, like the water, is flat. The key parameters that determine the vapor cloud dispersion are the wind direction, the wind speed, and the atmospheric stability coefficient.

In application, the VM is one of the key components of the U.S. Coast Guard Risk Management System, a system of analytical models for (1) identifying and assessing the principal spill risks associated with hazardous materials marine transportation and (2) determining the cost benefits of alternative safety regulations or actions which reduce the risks.

The VM is a planning tool and not a quick-reaction model to assist in the response to actual hazardous materials spills. It is to be used in regulatory or safety systems analysis to assist in the design and evaluation of alternative means to reduce the hazards of marine spills. In this type of application, the VM is used to determine the effect on consequences of alternative safety measures and actions. Typical applications are:

- *terminal or facility siting* (evaluation of the relative hazards of alternative sites),
- *facility design* (evaluation of the effect on consequences of alternative safety measures),
- *vessel safety analysis* (evaluation of the effect on consequences of alternative means to reduce spill potential),
- *traffic control systems analysis* (evaluation of the effect on consequences of alternative traffic control schemes),
- *spill response analysis* (evaluation of the effect on consequences of alternative means of spill containment).

Appendix B

UIM FLOWCHART AND SOURCE CODES

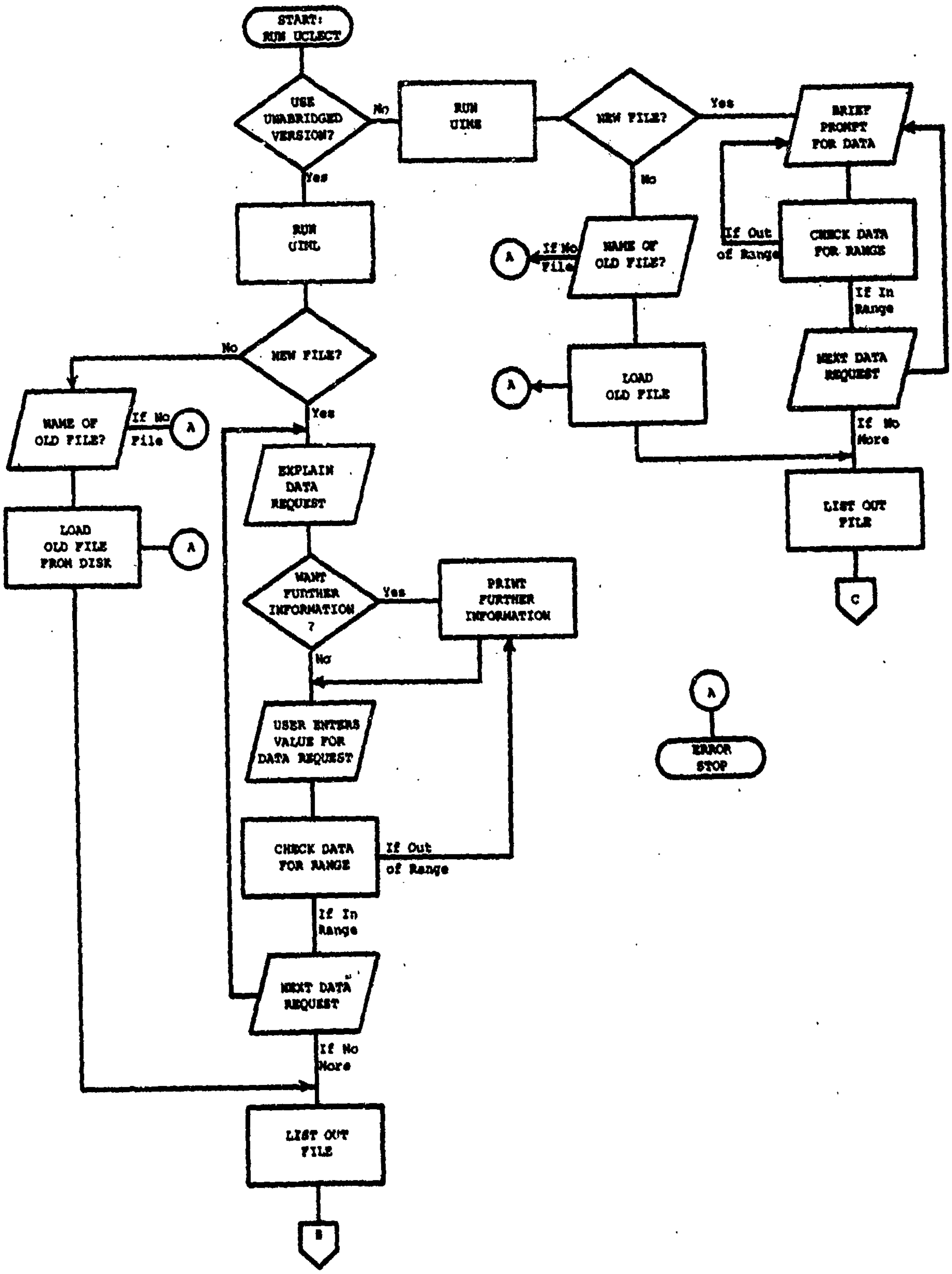
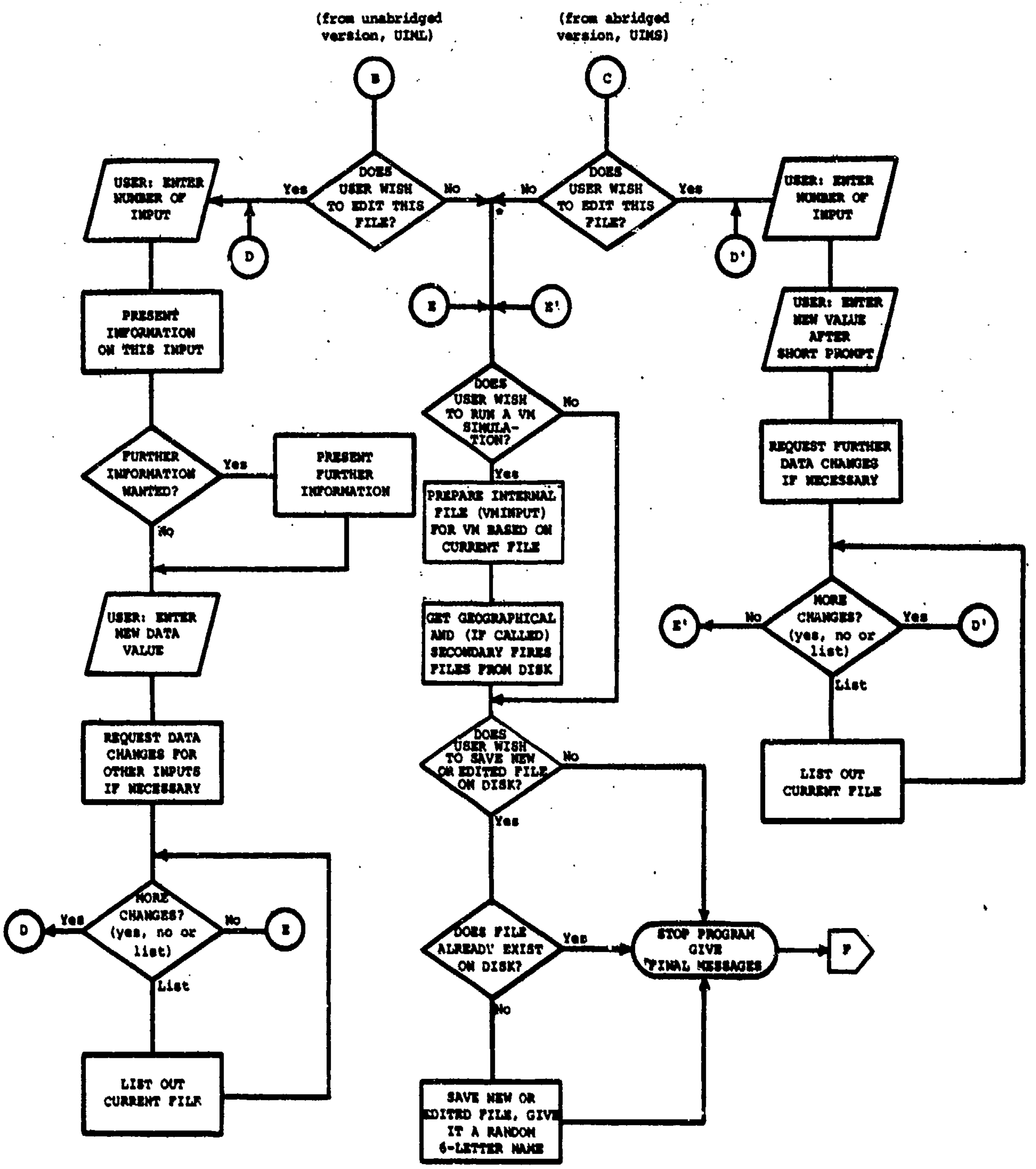


FIGURE B-1. UIM Flowchart (Part One)



*N.B.—Although this flowchart depicts the two programs as converging at this point, they are separate and do not interconnect. This is drawn as such only to illustrate the common format of UIMS and UIML.

FIGURE B-1. UIM Flowchart (Part Two)

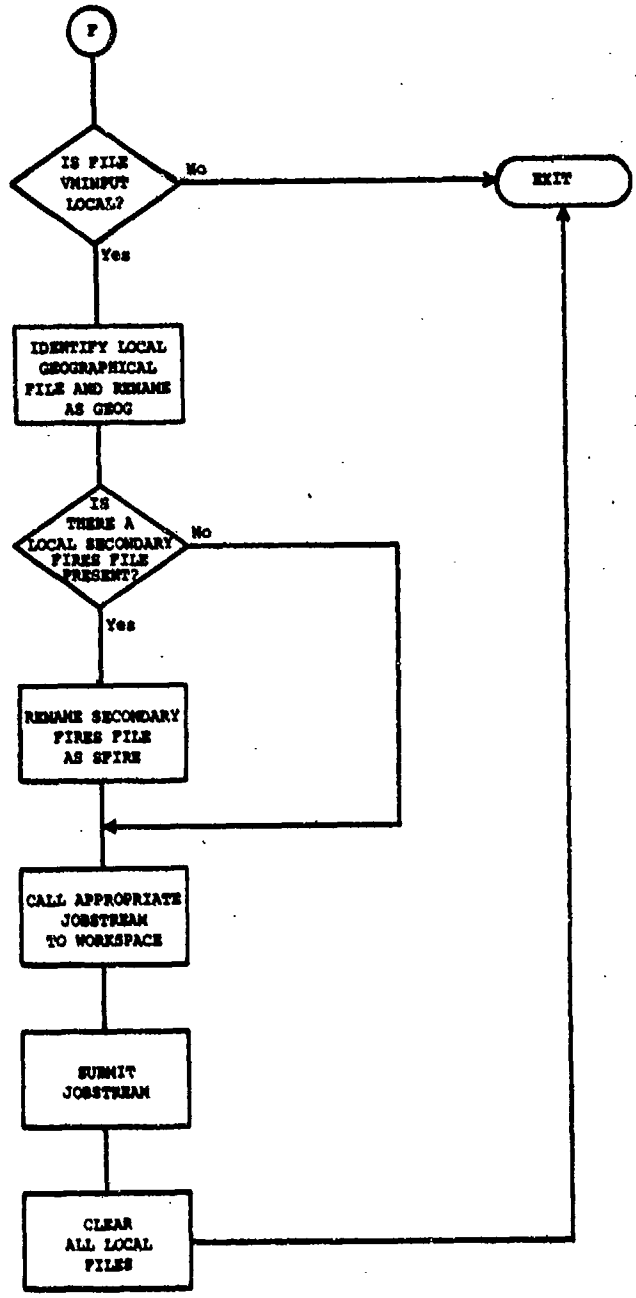


FIGURE B-1. UIM Flowchart (Part Three)

```
00010 BASE 1
00020 DIM Z(3,200)
00030 DIM C3(27,18)
00040 GOSUB 07370
00050 F4=0
00060 F5=0
00070 M5$=#NO#
00080 Z(1,25)=3004
00090 F8=0
00100 PRINT #PLEASE ENTER YOUR LAST NAME AND THE TITLE OF #
00110 PRINT #THIS SPILL SIMULATION IN THAT ORDER--#
00120 PRINT
00130 PRINT #EXAMPLE-- SMITH/LNG SPILL  NEW YORK#
00140 INPUT N1$
00150 PRINT
00160 PRINT
00170 N2$=DAT$
00180 GOTO 10300
00190 INPUT V$
00200 IF V$=#OLD# THEN 00230
00210 X$=#PREPARED#
00220 GOTO 00240
00230 X$=#REQUESTED#
00240 IF V$ = #OLD# OR V$=#NEW# THEN 00280
00250 PRINT #INPUT MUST BE EITHER NEW OR OLD#
00260 PRINT #PLEASE REENTER#
00270 GOTO 00190
00280 IF V$=#OLD# THEN 09540
00290 GOSUB 09430
00300 PRINT
00310 B3=0
00320 IF F6=1 THEN 10460
00330 INPUT W$
00340 IF W$ =#MKS# OR W$=#BRITISH# THEN 00380
00350 PRINT #YOUR ANSWER MUST BE EITHER MKS OR BRITISH.#
00360 PRINT #PLEASE RETYPE YOUR ANSWER#
00370 GOTO 00330
00380 IF W$=#MKS# THEN 00410
00390 F1=1
00400 GO TO 00420
00410 F1=2
00420 Z(1,120)=20
00430 Z(2,120)=F1
00440 PRINT
00450 IF F6=1 THEN 00520
00460 INPUT W$
00470 IF W$=#INFO# OR W$=#INPUT# THEN 00510
00480 PRINT #YOUR ANSWER MUST BE EITHER INFO OR INPUT#
00490 PRINT #PLEASE RETYPE YOUR ANSWER#
00500 GOTO 00460
00510 IF W$=#INPUT# THEN 00520
00520 IF F1=1 THEN 00590
00530 O1$=#CELSIUS.#
00540 O2$=#CUBIC METERS.#
00550 O3$=#METERS.#
00560 O4$=#METERS PER SECOND.#
00570 IF F6=1 THEN 10520
00580 GOTO 00640
00590 O1$=#FAHRENHEIT.#
00600 O2$=#THOUSANDS OF GALLONS.#
00610 O3$=#FEET.#
00620 O4$=#FEET PER SECOND.#
00630 IF F6=1 THEN 10520
00640 IF F5=1 THEN 09630
00650 INPUT W
```

FIGURE B-2.   Program UIMS

```
00660 Z(2,2)=W
00670 Z(1,2)=2004
00680 IF F1=2 THEN 00710
00690 Z(3,2)=(W-32)*(5/9)
00700 GOTO 00720
00710 Z(3,2)=W
00720 Z(1,103)=2036
00730 IF W<-200 OR W>300 THEN 00750
00740 GOTO 00770
00750 PRINT "ERROR--CARGO TEMP. IS OUT OF RANGE. RE-ENTER VALUE OR STOP---"
00760 GOTO 00650
00770 Z(3,103)=Z(3,2)
00780 IF F4=1 THEN 06400
00790 IF F6=1 THEN 10630
00800 INPUT W
00810 Z(2,3)=W
00820 Z(1,3)=2005
00830 Z(3,3)=W*1000000
00840 IF F4=1 THEN 06400
00850 IF F6=1 THEN 10660
00860 INPUT W
00870 Z(2,4)=W
00880 Z(1,4)=2001
00890 IF F1=2 THEN 00920
00900 Z(3,4)=W*3785000
00910 GOTO 00930
00920 Z(3,4)=W*1000000
00930 IF F4=1 THEN 01060
00940 IF F6=1 THEN 10700
00950 INPUT W
00960 Z(2,5)=W
00970 Z(1,5)=2002
00980 IF F1=2 THEN 01010
00990 Z(3,5)=W*30.48
01000 GOTO 01020
01010 Z(3,5)=W*100
01020 IF F4=1 THEN 06400
01030 IF F6=1 THEN 10740
01040 Z(2,6)=W
01050 Z(1,6)=2007
01060 Z(3,6)=Z(3,130)*Z(3,4)*Z(2,6)
01070 IF F4=1 THEN 06400
01080 IF F6=1 THEN 10800
01090 INPUT W
01100 IF W>0 THEN 01130
01110 PRINT "ERROR-- HOLE SIZE MUST BE A POSITIVE, NON-ZERO NUMBER."
01120 GOTO 10810
01130 Z(2,7)=W
01140 Z(1,7)=2008
01150 IF F1=1 THEN 01180
01160 Z(3,7)=W*100
01170 GOTO 01190
01180 Z(3,7)=W*30.48
01190 Z(1,102)=2029
01200 IF Z(3,7)>100 THEN 01230
01210 Z(3,102)=1
01220 GOTO 01240
01230 Z(3,102)=0
01240 IF F4=1 THEN 06400
01250 IF F6=1 THEN 10840
01260 INPUT W
01270 Z(2,8)=W
01280 Z(1,8)=2015
01290 IF F1=1 THEN 01320
01300 Z(3,8)=W*100
01310 GOTO 01330
```

FIGURE B-2 (continued)

```
01320 Z(3,8)=W*30.48
01330 IF F4=1 THEN 06400
01340 IF F6=1 THEN 10870
01350 INPUT W
01360 Z(2,9)=W
01370 Z(1,9)=2003
01380 IF F1=2 THEN 01410
01390 Z(3,9)=W*30.48
01400 GOTO 01420
01410 Z(3,9)=W*100
01420 PRINT
01430 IF F4=1 THEN 06400
01440 IF F6=1 THEN 10900
01450 Z(2,10)=W
01460 Z(1,101)=2028
01470 Z(3,101)=W
01480 Z(1,10)=2013
01490 IF W=1 THEN 01520
01500 Z(3,10)=1
01510 GOTO 01530
01520 Z(3,10)=2
01530 IF F4=1 THEN 06580
01540 IF F6=1 THEN 10930
01550 INPUT.W
01560 Z(2,11)=W
01570 Z(1,11)=2023
01580 IF F1=1 THEN 01640
01590 IF W>-5 AND W<50 THEN 01620
01600 PRINT "ERROR== TEMPERATURE IS OUT OF RANGE."
01610 GOTO 10960
01620 Z(3,11)=W
01630 GOTO 01670
01640 Z(3,11)=(W-32)*(5/9)
01650 W=Z(3,11)
01660 GOTO 01590
01670 IF F4>0 THEN 06400
01680 IF F6=1 THEN 10980
01690 INPUT W
01700 Z(2,12)=W
01710 Z(1,12)=2020
01720 IF F1=1 THEN 01750
01730 Z(3,12)=W*100
01740 GOTO 01760
01750 Z(3,12)=W*30.48
01760 Z(1,104)=2045
01770 Z(3,104)=Z(3,12)
01780 IF F4=2 THEN 06400
01790 IF F6=1 THEN 11020
01800 GOTO 11020
01810 INPUT W
01820 Z(2,13)=W
01830 Z(1,13)=2044
01840 IF F1=1 THEN 01870
01850 Z(3,13)=W*100
01860 GOTO 01880
01870 Z(3,13)=W*30.48
01880 IF F4=2 THEN 06400
01890 IF F6=1 THEN 11050
01900 GOTO 11090
01910 INPUT W
01920 Z(2,14)=W
01930 Z(1,14)=2047
01940 IF F1=1 THEN 01970
01950 Z(3,14)=W*100
01960 GOTO 01980
```

FIGURE B-3 (continued)

```
01970 Z(3,14)=W*30.48
01980 IF F4=2 THEN 06400
01990 IF F6=1 THEN 11090
02000 GOTO 11090
02010 Z(2,15)=W
02020 Z(1,15)=2052
02030 IF W=2 OR W=3 THEN 02060
02040 Z(3,15)=.03
02050 GOTO 02100
02060 IF W=3 THEN 02090
02070 Z(3,15)=.05
02080 GOTO 02100
02090 Z(3,15)=.10
02100 PRINT
02110 IF F4=2 OR F4=1 THEN 06400
02120 IF F6=1 THEN 11160
02130 INPUT W
02140 Z(2,16)=W
02150 Z(1,16)=2016
02160 IF F1=1 THEN 02190
02170 Z(3,16)=W*100
02180 GOTO 02200
02190 Z(3,16)=W*30.48
02200 IF F4=1 THEN 06400
02210 IF F6=1 THEN 11180
02220 Z(2,17)=W
02230 Z(1,17)=2058
02240 Z(3,17)=W
02250 IF F4=1 THEN 06400
02260 IF F6=1 THEN 11270
02270 Z(1,19)=2017
02280 W9$=W$
02290 IF W$=#H# OR W$=#D# THEN 02320
02300 Z(3,19)=6
02310 GOTO 02360
02320 IF W$=#E# THEN 02350
02330 Z(3,19)=4
02340 GOTO 02360
02350 Z(3,19)=2
02360 PRINT
02370 IF F4=1 THEN 06400
02380 IF F6=1 THEN 11440
02390 INPUT W
02400 W=INT(W)
02410 IF W <=89 THEN 02450
02420 PRINT #DEGREES ENTRY FOR LATITUDE MUST BE LESS THAN 90.#
02430 PRINT #PLEASE RETYPE YOUR ANSWER.#
02440 GOTO 11440
02450 L1$=STR$(W)
02460 IF LEN(L1$)=2 THEN 02480
02470 L1$=#0#+L1$
02480 PRINT #NOW ENTER THE MINUTES.#
02490 INPUT W
02500 W=INT(W)
02510 IF W < 60 THEN 02550
02520 PRINT #MINUTES ENTRY MUST ALWAYS BE LESS THAN 60.#
02530 PRINT #PLEASE RETYPE YOUR ANSWER.#
02540 GOTO 02480
02550 L2$=STR$(W)
02560 IF LEN(L2$)=2 THEN 02580
02570 L2$=#0#+L2$
02580 PRINT #NOW ENTER THE SECONDS.#
02590 INPUT W
02600 W=ROF(W)
02610 W=INT(W)
02620 L7$=#.#
02630 IF W<>0 OR W<>0. THEN 02660
02640 L3$=#00#
02650 GOTO 02750
```

FIGURE B-2 (continued)

```
02660 IF W < 60 THEN 02700
02670 PRINT #SECONDS ENTRY MUST ALWAYS BE LESS THAN 60.#
02680 PRINT #PLEASE RETYPE YOUR ANSWER.#
02690 GOTO 02580
02700 W=ROF(W)
02710 W=INT(W)
02720 L3$=STR$(W)
02730 IF W>=10 THEN 02750
02740 L3$=#0#+L3$
02750 L$(1)=L1$+L2$+L3$+L7$
02760 Z(1,20)=6010
02770 PRINT
02780 IF F4=1 THEN 06400
02790 IF F6=1 THEN 11460
02800 INPUT W
02810 W=INT(W)
02820 IF W<180 THEN 02860
02830 PRINT #DEGREES ENTRY FOR LONGITUDE MUST BE LESS THAN 180.#
02840 PRINT #PLEASE RETYPE YOUR ANSWER.#
02850 GOTO 11460
02860 L4$=STR$(W)
02870 IF LEN(L4$)=3 THEN 02910
02880 L4$=#0#+L4$
02890 IF LEN(L4$)=3 THEN 02910
02900 L4$=#0#+L4$
02910 PRINT #NOW ENTER THE MINUTES.#
02920 INPUT W
02930 W=INT(W)
02940 IF W < 60 THEN 02980
02950 PRINT #MINUTES ENTRY MUST ALWAYS BE LESS THAN 60#
02960 PRINT #PLEASE RETYPE YOUR ANSWER.#
02970 GOTO 02910
02980 L5$=STR$(W)
02990 IF LEN(L5$)=2 THEN 03010
03000 L5$=#0#+L5$
03010 PRINT #NOW ENTER THE SECONDS.#
03020 INPUT W
03030 IF W < 60 THEN 03070
03040 PRINT #SECONDS ENTRY MUST BE LESS THAN 60.#
03050 PRINT #PLEASE RETYPE YOUR ANSWER.#
03060 GOTO 03010
03070 W=ROF(W)
03080 L6$=STR$(W)
03090 L7$=#.#
03100 IF W>=10 THEN 03120
03110 L6$=#0#+L6$
03120 L$(2)=L4$+L5$+L6$+L7$
03130 Z(1,21)=6011
03140 IF F4=1 THEN 06400
03150 PRINT
03160 IF F6=1 THEN 11460
03170 INPUT W
03180 IF W=1 OR W=2 OR W=3 OR W=4 THEN 03220
03190 PRINT # YOUR ANSWER MUST BE 1, 2, 3, OR 4.#
03200 PRINT #PLEASE RETYPE YOUR ANSWER.#
03210 GOTO 03170
03220 Z(1,23)=5003
03230 Z(1,105)=5004
03240 Z(1,106)=5006
03250 Z(2,23)=W
03260 IF Z(2,23)=1 OR Z(2,23)=4 THEN 03290
03270 Z(3,106)=Z(2,23)
03280 GOTO 03300
03290 Z(3,106)=0
03300 IF Z(3,144)=1 AND Z(3,145)=1 THEN 03380
03310 IF Z(3,145)=1 THEN 03380
03320 IF Z(2,23)=2 OR Z(2,23)=3 OR Z(2,23)=4 THEN 03380
```

FIGURE B-2 (continued)

```
03330 PRINT ≠THE CHEMICAL SPILLED IS NOT SUFFICIENTLY TOXIC TO CAUSE≠
03340 PRINT ≠SIGNIFICANT TOXIC DAMAGE. A RUN REQUESTING FIRE DAMAGE IS≠
03350 PRINT ≠RECOMMENDED.≠
03360 IF F6=1 THEN 11520
03370 GOTO 11530
03380 IF Z(2,23)=1 THEN 03410
03390 Z(3,23)=1
03400 GOTO 03420
03410 Z(3,23)=0
03420 REM ≠THIS TO EDIT TYPE OF CHEMICAL≠
03430 IF Z(3,144)=1 AND Z(3,145)=1 THEN 03490
03440 IF Z(3,144)=1 THEN 03490
03450 IF Z(2,23)=1 THEN 03490
03460 PRINT ≠THE CHEMICAL SPILLED IS NOT FLAMMABLE, HENCE THERE CAN BE≠
03470 PRINT ≠NO FIRE DAMAGE. A RUN REQUESTING TOXIC DAMAGE IS RECOMMENDED.≠
03480 IF F6=1 THEN 11530
03490 IF Z(2,23)=1 THEN 03520
03500 Z(3,105)=0
03510 GOTO 03530
03520 Z(3,105)=1
03530 PRINT
03540 IF F4=1 THEN 06880
03550 IF F6=1 THEN 11550
03560 INPUT W
03570 G4=0
03580 IF W>1000 AND W<9999 THEN 03620
03590 PRINT ≠YOUR ANSWER MUST BE A FOUR(4) DIGIT CODE.≠
03600 PRINT ≠PLEASE RETYPE YOUR ANSWER.≠
03610 GOTO 03560
03620 Z(2,24)=W
03630 GOSUB 13080
03640 IF G4<>1 THEN 03660
03650 GOTO 03560
03660 Z(1,24)=10
03670 IF F4=1 THEN 06400
03680 IF F6=1 AND Z(2,23)=1 THEN 11680
03690 PRINT
03700 IF F6=1 THEN 11570
03710 PRINT
03720 PRINT ≠START OF FIRST TIME SEQUENCE IN SECONDS AFTER THE≠
03730 PRINT ≠SPILL OCCURS.≠
03740 INPUT W
03750 Z(2,27)=W
03760 Z(3,27)=W
03770 IF F4=1 THEN 06400
03780 PRINT ≠TIME BETWEEN DAMAGE COMPUTATIONS IN SECONDS.≠
03790 INPUT W
03800 Z(2,29)=W
03810 Z(3,29)=W
03820 IF F4=1 THEN 06400
03830 PRINT ≠END OF FIRST TIME SEQUENCE IN SECONDS AFTER SPILL OCCURS.≠
03840 INPUT W
03850 Z(3,28)=W
03860 Z(2,28)=W
03870 IF F4=1 THEN 06400
03880 PRINT ≠START OF SECOND TIME SEQUENCE IN MINUTES AFTER THE ≠
03890 PRINT ≠SPILL OCCURS.≠
03900 INPUT W
03910 Z(2,30)=W
03920 Z(3,30)=W
03930 IF F4=1 THEN 06400
03940 PRINT ≠TIME BETWEEN DAMAGE COMPUTATIONS IN MINUTES.≠
03950 INPUT W
03960 Z(2,32)=W
03970 Z(3,32)=W
03980 IF F4=1 THEN 06400
03990 PRINT ≠END OF SECOND TIME SEQUENCE IN MINUTES AFTER SPILL OCCURS.≠
```

FIGURE B-2 (continued)

```
04000 INPUT W
04010 Z(2,31)=W
04020 Z(3,31)=W
04030 IF F4=1 THEN 06400
04040 PRINT #START OF THIRD TIME SEQUENCE IN MINUTES AFTER THE#
04050 PRINT #SPILL OCCURS.#
04060 INPUT W
04070 Z(2,33)=W
04080 Z(3,33)=W
04090 IF F4=1 THEN 06400
04100 PRINT #TIME BETWEEN DAMAGE COMPUTATIONS IN MINUTES:#
04110 INPUT W
04120 Z(2,35)=W
04130 Z(3,35)=W
04140 IF F4=1 THEN 06400
04150 PRINT #END OF THIRD TIME SEQUENCE IN MINUTES AFTER SPILL INITIATION.#
04160 INPUT W
04170 Z(2,34)=W
04180 Z(3,34)=W
04190 IF F4=1 THEN 06400
04200 Z(1,27)=6001
04210 Z(1,29)=6003
04220 Z(1,28)=6002
04230 Z(1,30)=6004
04240 Z(1,32)=6006
04250 Z(1,31)=6005
04260 Z(1,33)=6007
04270 Z(1,35)=6009
04280 Z(1,34)=6008
04290 IF F4=1 THEN 06400
04300 IF W$<>#NO# THEN 04690
04310 IF Z(3,105)=1 THEN 04670
04320 REM #USE DEFAULT TIME SEQ#
04330 T=Z(2,22)/(60*Z(2,16))
04340 FOR I=1 TO 9
04350 I2=26+I
04360 Z(2,I2)=0
04370 Z(3,I2)=0
04380 NEXT I
04390 IF Z(3,106)=0 THEN 04430
04400 Z(3,27)=1
04410 Z(3,28)=20
04420 Z(3,29)=2
04430 IF T > 10 THEN 04480
04440 Z(3,30)=2
04450 Z(3,32)=2
04460 Z(3,31)=0
04470 GOTO 04650
04480 IF T>100 THEN 04570
04490 T1=INT((T/5))
04500 T1=T1*5
04510 Z(3,30)=5
04520 Z(3,31)=T1
04530 Z(3,32)=5
04540 Z(3,34)=T1+80
04550 Z(3,35)=2
04560 GOTO 04650
04570 T1=INT((T/50))
04580 Z(3,30)=50
04590 T1=T1*50
04600 Z(3,31)=T1
04610 Z(3,32)=50
04620 Z(3,33)=T1
04630 Z(3,34)=T1+80
04640 Z(3,35)=2
04650 IF F4=1 THEN 06400
04660 GOTO 04690
```

FIGURE B-2 (continued)

```
04670 Z(3,30)=Z(3,31)=80
04680 Z(3,32)=1
04690 PRINT #DO YOU WANT TO SEE THE LISTING OF YOUR INPUTS, (YES OR NO)#
04700 INPUT W$
04710 IF W$=#NO# THEN 05730
04720 PRINT
4725 IF F4>=1 THEN 4727
4726 GOTO 4730
4727 X$=#EDITED#
04730 PRINT #THE FOLLOWING IS A LIST OF THE #;V$;# FILE YOU HAVE #;X$
04740 PRINT
04750 PRINT #THE UNITS OF MEASUREMENT ARE:#
04760 PRINT TAB(10);#PRESSURE-#,#ATMOSPHERES.#
04770 PRINT TAB(10);#TEMPERATURE=#;O1$
04780 PRINT TAB(10);#LENGTH-#;O3$
04790 PRINT TAB(10);#VOLUME=#;O2$
04800 PRINT TAB(10);#VELOCITY-#;O4$
04810 PRINT
04820 REM #LIST OUT THE UIM FILE TO THE TERMINAL#
04830 PRINT USING 04840
04840 :  NUMBER OF INPUT    NAME OF INPUT                    USER INPUT
04850 PRINT
04860 PRINT USING 04870,M1$
04870 :             1          CHEMICAL CODE                     >'''''''''''
04880 PRINT USING 04890,Z(2,2)
04890 :             2          CARGO TEMPERATURE                    ####.##
04900 PRINT USING 04910,Z(2,3)
04910 :             3          TANK PRESSURE                         ###.#
04920 PRINT USING 04930,Z(2,4)
04930 :             4          TANK CAPACITY                    #######.##
04940 PRINT USING 04950,Z(2,5)
04950 :             5          TANK HEIGHT                           ###.##
04960 PRINT USING 04970,Z(2,6)
04970 :             6          FRACTION TANK FILLED                   #.##
04980 PRINT USING 04990,Z(2,7)
04990 :             7          HOLE DIAMETER                         ###.##
05000 PRINT USING 05010,Z(2,8)
05010 :             8          HEIGHT OF CENTERLINE                 ####.##
05020 PRINT USING 05030,Z(2,9)
05030 :             9          HEIGHT OF HOLE BOTTOM                 ###.##
05040 PRINT USING 05050,Z(2,10)
05050 :            10          SPILL LOCATION                             #
05060 PRINT USING 05070,Z(2,11)
05070 :            11          WATER TEMPERATURE                     ###.##
05080 IF Z(2,10)=1 THEN 05170
05090 PRINT USING 05100,Z(2,12)
05100 :            12          CHANNEL WIDTH                        ####.##
05110 PRINT USING 05120,Z(2,13)
05120 :            13          AVERAGE RIVER DEPTH                   ###.##
05130 PRINT USING 05140,Z(2,14)
05140 :            14          AVERAGE RIVER VELOCITY                 ##.##
05150 PRINT USING 05160,Z(2,15)
05160 :            15          TYPE OF RIVER BANKS                        #
05170 PRINT USING 05180,Z(2,16)
05180 :            16          AVERAGE WIND SPEED                    ###.##
05190 PRINT USING 05200,Z(2,17)
05200 :            17          WIND DIRECTION                         ###.#
05210 PRINT USING 05220,Z(2,18)
05220 :            18          AIR TEMPERATURE                      ####.##
05230 PRINT USING 05240,M9$
05240 :            19          ATMOSPHERIC STABILITY CODE        >''''''''''
05250 IF V$=#NEW# THEN 05290
05260 LET L1$=SUBSTR(L$(1),1,2)
05270 LET L2$=SUBSTR(L$(1),3,2)
05280 LET L3$=SUBSTR(L$(1),5,2)
```

FIGURE B-2 (continued)

```
05290 PRINT USING 05300,L1$,L2$,L3$
05300 :              20              DEGREES LATITUDE                 >≡≡ >≡≡ >≡≡
05310 IF V$=≠NEW≠ THEN 05350
05320 LET L4$=SUBSTR(L$(2),1,3)
05330 LET L5$=SUBSTR(L$(2),4,2)
05340 LET L6$=SUBSTR(L$(2),6,2)
05350 PRINT USING 05360,L4$,L5$,L6$
05360 :              21              DEGREES LONGITUDE               >≡≡≡ >≡≡ >≡≡
05370 PRINT USING 05380,Z(2,22)
05380 :              22              DISTANCE OF SPILL TO SHORE         ≡≡≡≡≡.≡≡
05390 PRINT USING 05400,Z(2,23)
05400 :              23              TYPE OF DAMAGE                            ≡
05410 PRINT USING 05420,Z(2,24)
05420 :              24              GEOGRAPHICAL FILE                      ≡≡≡≡
05430 IF Z(2,23)=1 THEN 05460
05440 PRINT USING 05450,M5$
05450 :              25              SECONDARY FIRES                        >≡≡≡
05460 PRINT USING 05470,Z(2,26)
05470 :              26              POPULATION SHELTERED                   ≡.≡≡
05480 B3=0
05490 Z(1,121)=30
05500 IF B3$=≠NO≠ THEN 05710
05510 B3=1
05520 PRINT USING 05530,Z(2,27)
05530 :              27              BEGIN FIRST TIME SEQUENCE           ≡≡≡≡
05540 PRINT USING 05550,Z(2,29)
05550 :              28              BETWEEN FIRST TIME SEQUENCE          ≡≡≡
05560 PRINT USING 05570,Z(2,28)
05570 :              29              END FIRST TIME SEQUENCE             ≡≡≡≡
05580 PRINT USING 05590,Z(2,30)
05590 :              30              BEGIN SECOND TIME SEQUENCE          ≡≡≡≡
05600 PRINT USING 05610,Z(2,32)
05610 :              31              BETWEEN SECOND TIME SEQUENCE         ≡≡≡
05620 PRINT USING 05630,Z(2,31)
05630 :              32              END SECOND TIME SECUENCE            ≡≡≡≡
05640 PRINT USING 05650,Z(2,33)
05650 :              33              BEGIN THIRD TIME SEQUENCE           ≡≡≡≡
05660 PRINT USING 05670,Z(2,35)
05670 :              34              BETWEEN THIRD TIME SEQUENCE          ≡≡≡
05680 PRINT USING 05690,Z(2,34)
05690 :              35              END THIRD TIME SEQUENCE             ≡≡≡≡
05700 GOTO 05720
05710 B3=0
05720 PRINT
05730 PRINT
05740 PRINT
05750 PRINT ≠DO YOU WANT TO MAKE ANY CHANGES TO≠
05760 PRINT ≠ THE CONTENTS OF THIS FILE (YES OR NO)≠;
05770 INPUT X2$
05780 IF X2$=≠NO≠ THEN 05830
05790 IF X2$=≠YES≠ THEN 05820
05800 PRINT ≠YOUR ANSWER MUST BE EITHER YES OR NO.≠
05810 GOTO 05750
05820 GOTO 05970
05830 PRINT
05840 PRINT ≠DO YOU WANT TO RUN A VM SIMULATION≠
05850 PRINT ≠USING THESE DATA≠;
05860 INPUT Y$
05870 IF Y$=≠YES≠ OR Y$=≠NO≠ THEN 06000
05880 PRINT ≠PLEASE ENTER EITHER YES OR NO.≠
05890 GOTO 05840
05900 IF W$=≠LIST≠ THEN 04760
05910 IF W$=≠YES≠ AND K$<>≠YES≠ THEN 05970
05920 IF W$=≠NO≠ THEN 05830
05930 IF W$=≠YES≠ THEN 06170
05940 PRINT ≠YOUR ANSWER MUST BE EITHER YES OR NO.≠
05950 PRINT ≠PLEASE RETYPE YOUR ANSWER.≠
05960 GOTO 06460
```

FIGURE B-2 (continued)

```
05970 F4=1
05980 PRINT #INPUT NUMBER#;
05990 GOTO 06200
06000 PRINT
06010 PRINT #DO YOU WANT TO SAVE THIS FILE ON DISK#;
06020 INPUT W$
06030 IF W$=#NO# THEN 06080
06040 IF W$=#YES# THEN 06070
06050 PRINT #A SIMPLE YES OR NO WILL DO.#
06060 GOTO 06010
06070 GOTO 06100
06080 IF Y$=#NO# THEN 13060
06090 IF Y$=#YES# THEN 11970
06100 IF F8=0 AND F4>0 THEN 06130
06110 IF F8=0 THEN 09410
06120 IF F8=1 THEN 06150
06130 E$=D$
06140 GOSUB 09430
06150 GOSUB 08180
06160 GOTO 06080
06170 PRINT #PLEASE ENTER THE NUMBER OF THE INPUT THAT YOU WANT#
06180 PRINT #TO CHANGE.#
06190 F4=1
06200 INPUT C
06210 C=INT(C)
06220 IF K$<>#YES# AND C>0 AND C<36 THEN 06250
06230 PRINT #VALID RESPONSES ARE NUMBERS FROM 1 TO 35 ONLY.#
06240 GOTO 06170
06250 IF C=1 THEN 06360
06260 IF C>10 THEN 06280
06270 ON C GOTO 06360 , 10590 , 10630 , 10660 , 10700 , 10740 , 10800 , 10840 , 10
06280 IF C>20 THEN 06310
06290 C=C-10
06300 ON C GOTO 10960 , 06600 , 06600 , 06600 , 06600 , 11160 , 11180 , 11270 , 11
06310 IF C>30 THEN 07320
06320 C=C-20
06330 IF C>6 AND B3$<>#YES# THEN 07150
06340 ON C GOTO 11460 , 11480 , 06850 , 07350 , 07080 , 11680 , 03710 , 03780 , 03
06350 PRINT USING 05570,Z(2,28)
06360 PRINT #TO CHANGE THE CHEMICAL CODE YOU MUST DO SO BY CREATING#
06370 PRINT #A NEW FILE. EDITING THE CHEMICAL CODE IS NOT POSSIBLE#
06380 PRINT #BECAUSE OF THE DEPENDENCY OF THE OTHER VARIABLES#
06390 PRINT #ON THE CHEMICAL PROPERTIES,ETC.#
06400 IF F6<>2 THEN 06430
06410 PRINT #MORE CHANGES(YES,NO OR LIST)#;
06420 GOTO 06460
06430 PRINT #DO YOU WANT TO CHANGE ANY OF YOUR OTHER INPUTS?#
06440 PRINT #INPUT YES OR NO.#
06450 PRINT #IF YOU NEED A LIST OF YOUR FILE ANSWER LIST.#
06460 INPUT W$
06470 GOTO 05900
06480 IF F6=2 THEN 10900
06490 PRINT #YOUR REQUEST TO CHANGE THE SPILL LOCATION WILL BE#
06500 PRINT #PROCESSED. HOWEVER PLEASE NOTE THAT 1) IF YOU ARE#
06510 PRINT #CHANGING FROM AN OPEN WATER LOCATION(CODE=1) TO A#
06520 PRINT #RIVER OR CHANNEL LOCATION FURTHER QUESTIONS ABOUT#
06530 PRINT #THE RIVER OR CHANNEL WILL BE ASKED OR 2) IF YOU ARE#
06540 PRINT #CHANGING FROM A RIVER OR CHANNEL LOCATION TO AN OPEN#
06550 PRINT #WATER LOCATION, YOUR PREVIOUS INPUTS WITH REGARD TO#
06560 PRINT #THE CHANNEL OR RIVER WILL BE IGNORED.#
06570 GOTO 10900
06580 IF Z(2,10)=1 THEN 06400
06590 GOTO 11000
06600 IF Z(2,10)=2 THEN 06650
06610 PRINT #THIS INPUT IS USED ONLY WHEN THE SPILL LOCATION IS IN A #
06620 PRINT #RIVER, YOUR PREVIOUS ANSWER SPECIFIED AN OPEN WATER SPILL#
06630 PRINT #LOCATION. THE EDITING PROCESS CANNOT ENABLE.#
06640 GOTO 06400
```

FIGURE B-2 (continued)

```
06650 C=C-1
06660 F4=2
06670 ON C GOTO 11000 , 11020 , 11050 , 11090
06680 IF B3$=#NO# THEN 04320
06690 PRINT #   THE DISTANCE FROM THE SPILL TO SHORELINE VALUE#
06700 PRINT #IS USED BY THE PROGRAM TO CALCULATE THE DEFAULT TIME SEQUENCES.#
06710 PRINT #SINCE YOU OVERRODE THE TIME SEQUENCES, THIS INPUT HAS#
06720 PRINT #NO REAL MEANING. DO YOU WANT THESE SEQUENCES ERASED.#
06730 PRINT #IF YES, THE PROGRAM WILL COMPUTE THE TIME SEQUENCES#
06740 PRINT #USING THE NEW VALUE.#
06750 PRINT #INPUT YES OR NO.#
06760 INPUT W$
06770 IF W$=#YES# OR W$=#NO# THEN 06810
06780 PRINT #YOUR ANSWER MUST BE EITHER YES OR NO.#
06790 PRINT #PLEASE RETYPE YOUR ANSWER.#
06800 GOTO 06760
06810 IF W$=#NO# THEN 06400
06820 B3$=#YES#
06830 F4=1
06840 GOTO 04320
06850 T1=Z(2,23)
06860 PRINT #DAMAGE CODE(1,2,3 OR 4)#;
06870 GOTO 03170
06880 IF Z(2,23)=T1 THEN 06400
06890 IF T1>1 AND Z(2,23)>1 THEN 07020
06900 IF T1=1 AND Z(2,23)>1 THEN 06960
06910 PRINT
06920 PRINT #YOUR REQUESTED CHANGE TO TOXIC DAMAGE HAS BEEN PROCESSED.#
06930 PRINT #YOUR PREVIOUS INPUTS WITH REGARD TO FIRE DAMAGE WILL BE#
06940 PRINT #DISCARDED.#
06950 GOTO 06400
06960 F4=2
06970 PRINT
06980 PRINT #YOUR REQUESTED CHANGE TO FIRE DAMAGE HAS BEEN PROCESSED.#
06990 PRINT #THE PROGRAM WILL NOW ASK YOU FURTHER QUESTIONS NEEDED FOR#
07000 PRINT #THE VULNERABILITY MODEL IN MODELING FIRE DAMAGE.#
07010 GOTO 11570
07020 PRINT
07030 PRINT #YOUR REQUESTED CHANGE IN THE TYPE OF FIRE DAMAGE HAS BEEN#
07040 PRINT #PROCESSED. YOUR INPUTS WITH REGARD TO SECONDARY FIRES AND#
07050 PRINT #THE FRACTION OF THE POPULATION SHELTERED HAVE NOT CHANGED.#
07060 PRINT #YOU MAY EDIT THESE SEPARATELY IF YOU WISH TO CHANGE THEM.#
07070 GOTO 06400
07080 IF Z(2,23)>1 THEN 11570
07090 GOTO 07100
07100 PRINT #THIS USER INPUT IS ONLY USED WHEN REQUESTING THE VULNERABILITY#
07110 PRINT #MODEL TO SIMULATE FIRE DAMAGE. SINCE YOU REQUESTED A RUN#
07120 PRINT #MODELING TOXIC DAMAGE. THIS INPUT IS NOT USED. THE EDITING#
07130 PRINT #PROCESS CANNOT BE ENABLED.#
07140 GOTO 06400
07150 PRINT
07160 PRINT #THE PROGRAM HAS CALCULATED THE DEFAULT TIME SEQUENCES. PER#
07170 PRINT #YOUR REQUEST. DO YOU NOW WISH TO OVERRIDE THESE TIME SEQUENCES.#
07180 PRINT #INPUT EITHER YES OR NO.#
07190 INPUT W$
07200 IF W$=#YES# OR W$=#NO# THEN 07240
07210 PRINT #YOUR INPUT MUST BE EITHER YES OR NO.#
07220 PRINT #PLEASE RETYPE YOUR ANSWER.#
07230 GOTO 07190
07240 IF W$=#YES# THEN 072?0
07250 GOTO 06400
07260 B3$=#YES#
07270 PRINT #BECAUSE OF THE INTERDEPENDENCY OF THE TIME SEQUENCES, YOU#
07280 PRINT #WILL BE REQUESTED TO CHANGE ALL OF THEM DURING ONE EDIT.#
07290 PRINT
07300 F4=2
07310 GOTO 03710
```

FIGURE B-2 (continued)

```
07320 IF B3$<>#YES# THEN 07150
07330 C=C-30
07340 ON C GOTO 03940 , 03990 , 04040 , 04100 , 04150
07350 PRINT #GEOGRAPHIC FILE#;
07360 GOTO 03560
07370 REM #SUB TO SET UP CHEMICAL FILE#
07380 DATA 0,.841,36000,350.,1100,1,1,1,1,4,1.00,-9.9315,2.0488,0,0,.26,100,-26.
07390 DATA 0,.682,36000,0,1500,1, ,0,1,2,1.36,-28.33,2.27,0,0,100.,100,999
07400 DATA 0,1.59,0,0,0,1,0,0,1,0,2.50,-6.29,.408,0,0,1000,100,999
07410 DATA 0,1.424,0,0,0,1,0,0,1,0,2.64,-36.45,3.13,-2.4,2.9,3.4,100,999
07420 DATA 0,1.191,0,0,0,1,1,0,1,0,1.0,-16.85,2.804,0,0,10.,100,999
07430 DATA 0,.992,0,0,0,1,1,0,1,0,1.00,-25.87,3.354,2.798,2.9,52.,100,999
07440 DATA 0,.4150,13720,338.,1069,1,0,1,0,2,2.75,0,0,0,0,0,100,-161
07450 DATA 0,1.68,0,0,0,1,0,0,1,0,1.0,-56.81,5.27,0,0,1000,100,999
07460 DATA 0,1.38,0,0,0,1,0,0,1,0,1.00,-19.274,3.686,0,0,5.,100,999
07470 DATA 0,.699,0,0,0,1,1,0,1,0,1.43,-29.422,3.008,0,0,20,100,999
07480 DATA 0,1.374,36000,350.,1100,1,1,0,1,0,1.43,-31.343,3.008,0,0,70,100,999
07490 DATA 0,1.434,0,0,0,1,1,0,1,0,1.00,-15.67,2.1,0,0,10,100,999
07500 DATA 0,.58,15845,350.,1079,0,0,1,0,6.5,2.75,0,0,0,0,0,100,-60
07510 DATA 0,.60,15968,432.,1118,0,0,1,0,6,2.75,0,0,0,0,0,100,-79
07520 DATA 0,.70,15845,350.,1079,0,0,1,0,6,2.75,0,0,0,0,0,100,-45
07530 DATA 0,.55,15827,350.,1100,0,0,1,0,5.5,2.75,0,0,0,0,0,100,69
07540 DATA 0,.702,15903,350.,1078,0,0,1,0,12.5,2.75,0,0,0,0,0,100,-40
07550 DATA 0,.63,15867,385.,1077,0,0,1,0,8,2.75,0,0,0,0,0,100,-49
07560 DATA 0,.53,15809,390.,1130,0,0,1,0,5,2.75,0,0,0,0,0,100,-53
07570 DATA 0,.52,15968,350.,1112,0,0,1,0,4.5,2.75,0,0,0,0,0,100,-108
07580 DATA 0,.91,14613,350.,1100,0,0,1,0,2.5,2.75,0,0,0,0,0,100,-78
07590 DATA 0,.81,0,0,0,1,1,0,1,4.5,1.43,-29.42,3.008,0.,0.,1000,100,999
07600 DATA 0,.86,800.,350.,1174,1,1,1,1,4,2.0,-7.415,.509,0,0,1000,100,-37.
07610 DATA 0,.87,800.,350.,1130,1,0,1,1,9,2.5,-6.794,.408,0,0,1000,100,7.2
07620 DATA 0,.78,800,350.,1100.,1,1,1,0,2.5,2.75,0,0,0,0,1000,100,-38.
07630 DATA 0,.68,800,350,1100.,1,1,1,0,4.25,2.75,0,0,0,0,1000,100,-48.
07640 DATA 0,.92,800,350.,1100.,1,0,1,0,1.5,2.75,0,0,0,0,1000,100,0.
07650 MAT READ C3(27,18)
07660 RETURN
07670 REM #SUB TO EDIT THREE-CODE#
07680 F2=0.
07690 A3$=#ARLAMACBTCLXHDCHFXLNGMTBPHGHCNHDSSFD#
07700 FOR I=1 TO LEN(A3$) STEP 3
07710 IF SUBSTR(A3$,I,3)=W$ THEN 07800
07720 NEXT I
07730 I1=36
07740 A3$=#BUTBTNEETLPGOANPTAPHPPPLVCHACNPOXTOLAADDMAMTC#
07750 FOR K=1 TO LEN(A3$) STEP 3
07760 IF SUBSTR(A3$,K,3)=W$ THEN 07790
07770 NEXT K
07780 GOTO 07830
07790 I=I1+K
07800 F2=1
07810 K4=(I+2)/3
07820 GOSUB 07840
07830 RETURN
07840 REM #SUB TO SET-UP CHEMICAL PROPERTIES#
07850 Z(1,135)=2006
07860 Z(3,135)=C3(K4,1)
07870 Z(3,136)=C3(K4,2)
07880 Z(1,137)=2011
07890 Z(3,137)=C3(K4,3)
07900 Z(1,138)=2022
07910 Z(3,138)=1.0
07920 Z(1,139)=2033
07930 Z(3,139)=C3(K4,4)
07940 Z(1,140)=1019
07950 Z(3,140)=C3(K4,5)
07960 Z(1,141)=2043
07970 Z(3,141)=C3(K4,6)
07980 Z(1,142)=2046
07990 Z(3,142)=0.0
```

FIGURE B-2 (continued)

```
08000 Z(1,143)=5002
08010 Z(3,143)=C3(K4,7)
08020 Z(3,144)=C3(K4,8)
08030 Z(3,145)=C3(K4,9)
08040 Z(1,146)=5005
08050 Z(3,146)=0
08060 Z(1,147)=5019
08070 Z(3,147)=C3(K4,10)
08080 FOR I=1 TO 7
08090 I1=147+I
08100 I2=5029+I
08110 I3=10+I
08120 Z(1,I1)=I2
08130 Z(3,I1)=C3(K4,I3)
08140 NEXT I
08150 Z(1,155)=5020
08160 Z(3,155)=C3(K4,18)
08170 RETURN
08180 REM "THIS SUB USED FOR OUTPUT TO A FILE"
08190 D=1
08200 IF V$="NEW" THEN 08220
08210 D=3
08220 FILE #D=O$
08230 PRINT #D USING 08240,"UIF INPUT",N1$,N2$
08240 : #########   ##############################  #########,
08250 PRINT #D
08260 PRINT #D USING 08270,M1$,M1$
08270 :1001 ###              ,###,
08280 PRINT #D USING 08290,Z(1,24),Z(2,24),Z(2,22)
08290 :  ## ####             #####.##
08300 PRINT #D USING 08310,Z(1,120),F1
08310 :  ##                  #
08320 PRINT #D USING 08330,Z(1,121),B3
08330 :  ##                  #
08340 PRINT #D USING 08350,Z(1,4),Z(3,4),Z(2,4)
08350 :#### #.####%%%%      #######.##
08360 PRINT #D USING 08370,Z(1,5),Z(3,5),Z(2,5)
08370 :#### #####.#         ###.##
08380 PRINT #D USING 08390,Z(1,9),Z(3,9),Z(2,9)
08390 :#### ####.#          ###.##
08400 PRINT #D USING 08410,Z(1,2),Z(3,2),Z(2,2)
08410 :#### ####.##         ####.##
08420 PRINT #D USING 08430,Z(1,3),Z(3,3),Z(2,3)
08430 :#### #.####%%%%      ###
08440 PRINT #D USING 08450,Z(1,135),Z(3,135)
08450 :#### #.
08460 PRINT #D USING 08470,Z(1,6),Z(3,6),Z(2,6)
08470 :#### #.####%%%%      #.##
08480 PRINT #D USING 08490,Z(1,7),Z(3,7),Z(2,7)
08490 :#### #.####%%%%      ###.##
08500 PRINT #D USING 08510,Z(1,137),Z(3,137)
08510 :#### #.####%%%%
08520 PRINT #D USING 08530,Z(1,8),Z(3,8),Z(2,8)
08530 :#### ####.           ####.##
08540 PRINT #D USING 08550,Z(1,16),Z(3,16),Z(2,16)
08550 :#### ####.           ###.##
08560 PRINT #D USING 08570,Z(1,19),Z(3,19),M$$
08570 :#### #.              #,
08580 PRINT #D USING 08590,Z(1,10),Z(3,10),Z(2,10)
08590 :####                 #.  #
08600 IF Z(2,10)=1 THEN 08630
08610 PRINT #D USING 08620,Z(1,12),Z(3,12),Z(2,12)
08620 :#### #.####%%%%      ####.##
08630 PRINT #D USING 08640,Z(1,138),Z(3,138)
08640 :####                 #.
08650 PRINT #D USING 08660,Z(1,11),Z(3,11),Z(2,11)
08660 :#### ###.##          ###.##
```

FIGURE B-2 (continued)

```
08670 PRINT ≡C USING 08680,Z(1,139),Z(3,139)
08680 :≡≡≡≡ ≡≡≡≡.≡≡≡
08690 PRINT ≡C USING 08700,Z(1,101),Z(3,101)
08700 :≡≡≡≡            ≡.
08710 PRINT ≡D USING 08720,Z(1,102),Z(3,102)
08720 :≡≡≡≡            ≡.
08730 PRINT ≡D USING 08740,Z(1,140),Z(3,140)
08740 :≡≡≡≡ ≡≡≡≡.
08750 PRINT ≡D USING 08760,Z(1,103),Z(3,103)
08760 :≡≡≡≡ ≡≡≡≡.≡≡
08770 PRINT ≡D USING 08780,Z(1,141),Z(3,141)
08780 :≡≡≡≡ ≡≡≡≡≡≡.≡≡≡
08790 IF Z(2,10)=1 THEN 08840
08800 PRINT ≡D USING 08810,Z(1,13),Z(3,13),Z(2,13)
08810 :≡≡≡≡ ≡≡≡≡.           ≡≡≡≡.≡≡
08820 PRINT ≡D USING 08830,Z(1,104),Z(3,104)
08830 :≡≡≡≡ ≡.≡≡≡≡%%%%
08840 PRINT ≡D USING 08850,Z(1,142),Z(3,142)
08850 :≡≡≡≡ ≡.≡
08860 IF Z(2,10)=1 THEN 08910
08870 PRINT ≡C USING 08880,Z(1,14),Z(3,14),Z(2,14)
08880 :≡≡≡≡ ≡≡≡≡.≡           ≡≡.≡≡
08890 PRINT ≡D USING 08900,Z(1,15),Z(3,15),Z(2,15)
08900 :≡≡≡≡            ≡.    ≡
08910 PRINT ≡C USING 08920,Z(1,18),Z(3,18),Z(2,18)
08920 :≡≡≡≡ ≡≡≡≡.≡≡         ≡≡≡≡.≡≡
08930 PRINT ≡D USING 08940,Z(1,17),Z(3,17),Z(2,17)
08940 :≡≡≡≡ ≡≡≡.≡≡          ≡≡≡.≡
08950 PRINT ≡D USING 08960,Z(1,25),Z(3,25),Z(2,25)
08960 :≡≡≡≡            ≡.   ≡
08970 PRINT ≡D USING 08980,Z(1,143),Z(3,143)
08980 :≡≡≡≡            ≡.
08990 PRINT ≡D USING 09000,Z(1,23),Z(3,23),Z(2,23)
09000 :≡≡≡≡            ≡.    ≡
09010 PRINT ≡D USING 09020,Z(1,105),Z(3,105),M$$
09020 :≡≡≡≡            ≡.    >≡≡≡,
09030 PRINT ≡D USING 09040,Z(1,106),Z(3,106)
09040 :≡≡≡≡            ≡.
09050 PRINT ≡D USING 09060,Z(1,147),Z(3,147)
09060 :≡≡≡≡ ≡≡≡.
09070 PRINT ≡C USING 09080,Z(1,155),Z(3,155)
09080 :≡≡≡≡ ≡≡≡≡.≡
09090 FOR K=148 TO 154
09100 PRINT ≡D USING 09110,Z(1,K),Z(3,K)
09110 :≡≡≡≡ ≡≡≡≡.≡≡≡≡
09120 NEXT K
09130 PRINT ≡C USING 09140,Z(1,26),Z(3,26),Z(2,26)
09140 :≡≡≡≡ ≡.≡≡          ≡.≡≡
09150 FOR K=27 TO 35
09160 PRINT ≡D USING 09170,Z(1,K),Z(3,K),Z(2,K)
09170 :≡≡≡≡ ≡≡≡≡.          ≡≡≡≡.
09180 NEXT K
09190 PRINT ≡C USING 09200,Z(1,20),L$(1),L$(1)
09200 :≡≡≡≡ ≡≡≡≡≡≡≡≡≡≡    ,≡≡≡≡≡≡≡≡≡≡,
09210 PRINT ≡C USING 09220,Z(1,21),L$(2),L$(2)
09220 :≡≡≡≡ ≡≡≡≡≡≡≡≡≡≡    ,≡≡≡≡≡≡≡≡≡≡,
09230 PRINT ≡C
09240 IF D=3 THEN 09330
09250 D1$=#SAVE,#+D$
09260 CLOSE ≡D: D1$
09270 PRINT #A NEW FILE HAS BEEN SAVED FOR YOU#
09280 PRINT USING 09290,D$
09290 :THE NAME OF THE NEW FILE IS ≡≡≡≡≡≡
09300 PRINT #PLEASE REMEMBER IT FOR FURTHER USE.#
09310 PRINT
09320 RETURN
```

FIGURE B-2 (continued)

```
09330 REM #PROCEDURE TO SAVE THE NEW AND OLD FILES.#
09340 D1$=#SAVE,#+D5
09350 CLOSE ≡0: D1$
09360 CLOSE ≡2
09370 PRINT #THE NEW FILE HAS BEEN SAVED, ITS NAME IS #;C$;#.#
09380 PRINT #THE ORIGINAL FILE STILL EXISTS, ITS NAME IS STILL #;E$;#.#
09390 PRINT
09400 RETURN
09410 PRINT #THIS FILE ALREADY EXISTS ON DISK.#
09420 GOTO 06080
09430 REM #SUB USED TO GENER NAME#
09440 DATA A,B,C,D,E,F,G,H,I,J,K,L,M,N,O,P,Q,R,S,T,U,V,W,X,Y,Z
09450 DIM A1$(26)
09460 MAT READ A1$
09470 DIM A2$(6)
09480 FOR I=1 TO 6
09490 A2$(I)=A1$(INT((RND(-3)*25)+1))
09500 NEXT I
09510 F8=1
09520 D$=A2$(1)+A2$(2)+A2$(3)+A2$(4)+A2$(5)+A2$(6)
09530 RETURN
09540 REM #THIS PROCEDURE USED TO INPUT AN EXISTING FILE#
09550 INPUT ≡0,F$
09560 INPUT ≡0,F,F1$,M1$
09570 W$=M1$
09580 GOSUB 07670
09590 INPUT ≡0,Z(1,24),Z(2,24),Z(2,22)
09600 INPUT ≡0,Z(1,120),F1
09610 F5=1
09620 GOTO 00520
09630 INPUT ≡0,Z(1,121),B3
09640 IF B3=0 THEN 09670
09650 B3$=#YES#
09660 GOTO 09680
09670 B3$=#NO#
09680 INPUT ≡0,Z(1,4),Z(3,4),Z(2,4)
09690 REM #UNITS AND CHEMICAL PROPERTIES SET:#
09700 INPUT ≡0,Z(1,5),Z(3,5),Z(2,5)
09710 INPUT ≡0,Z(1,9),Z(3,9),Z(2,9)
09720 INPUT ≡0,Z(1,2),Z(3,2),Z(2,2)
09730 INPUT ≡0,Z(1,3),Z(3,3),Z(2,3)
09740 INPUT ≡0,Z(1,135),Z(3,135)
09750 INPUT ≡0,Z(1,6),Z(3,6),Z(2,6)
09760 INPUT ≡0,Z(1,7),Z(3,7),Z(2,7)
09770 INPUT ≡0,Z(1,137),Z(3,137)
09780 INPUT ≡0,Z(1,8),Z(3,8),Z(2,8)
09790 INPUT ≡0,Z(1,16),Z(3,16),Z(2,16)
09800 INPUT ≡0,Z(1,19),Z(3,19),M9$
09810 INPUT ≡0,Z(1,10),Z(3,10),Z(2,10)
09820 IF Z(2,10)=1 THEN 09840
09830 INPUT ≡0,Z(1,12),Z(3,12),Z(2,12)
09840 INPUT ≡0,Z(1,138),Z(3,138)
09850 INPUT ≡0,Z(1,11),Z(3,11),Z(2,11)
09860 INPUT ≡0,Z(1,139),Z(3,139)
09870 INPUT ≡0,Z(1,101),Z(3,101)
09880 INPUT ≡0,Z(1,102),Z(3,102)
09890 INPUT ≡0,Z(1,140),Z(3,140)
09900 INPUT ≡0,Z(1,103),Z(3,103)
09910 INPUT ≡0,Z(1,141),Z(3,141)
09920 IF Z(2,10)=1 THEN 09950
09930 INPUT ≡0,Z(1,13),Z(3,13),Z(2,13)
09940 INPUT ≡0,Z(1,104),Z(3,104)
09950 INPUT ≡0,Z(1,142),Z(3,142)
09960 IF Z(2,10)=1 THEN 09990
```

FIGURE B-2 (continued)

```
09970 INPUT ≡D,Z(1,14),Z(3,14),Z(2,14)
09980 INPUT ≡D,Z(1,15),Z(3,15),Z(2,15)
09990 INPUT ≡D,Z(1,18),Z(3,18),Z(2,18)
10000 INPUT ≡D,Z(1,17),Z(3,17),Z(2,17)
10010 INPUT ≡D,Z(1,25),Z(3,25),Z(2,25)
10020 INPUT ≡D,Z(1,143),Z(3,143)
10030 INPUT ≡D,Z(1,23),Z(3,23),Z(2,23)
10040 INPUT ≡D,Z(1,105),Z(3,105),M5$
10050 INPUT ≡D,Z(1,106),Z(3,106)
10060 INPUT ≡D,Z(1,147),Z(3,147)
10070 INPUT ≡D,Z(1,155),Z(3,155)
10080 FOR K=148 TO 154
10090 INPUT ≡D,Z(1,K),Z(3,K)
10100 NEXT K
10110 INPUT ≡D,Z(1,26),Z(3,26),Z(2,26)
10120 FOR K=27 TO 35
10130 INPUT ≡D,Z(1,K),Z(3,K),Z(2,K)
10140 NEXT K
10150 INPUT ≡D,Z(1,20),F$,L$(1)
10160 INPUT ≡D,Z(1,21),F$,L$(2)
10170 PRINT
10180 PRINT #FILE IS NOW LOADED.#
10190 RESTORE ≡D
10200 GOSUB 13080
10210 PRINT
10215 IF SUBSTR(N1$,1,8)=#SUPPRESS# THEN 4690
10220 IF K$<>#YES# THEN 04720
10230 IF F1=1 THEN 10270
10240 PRINT #THE FILE LOADED WAS CREATED USING MKS UNITS.#
10250 PRINT #ONLY MKS UNITS CAN BE USED DURING EDITING.#
10260 GO TO 04720
10270 PRINT #THE FILE LOADED WAS CREATED USING BRITISH UNITS.#
10280 PRINT #ONLY BRITISH UNITS CAN BE USED DURING EDITING.#
10290 GOTO 04720
10300 REM #SET-UP FOR SHORT VERSION CONDITIONAL BRANCHING.#
10310 PRINT
10320 PRINT #OLD OR NEW FILE#;
10330 INPUT V$
10340 IF V$=#OLD# THEN 10400
10350 IF V$=#NEW# THEN 10380
10360 PRINT #ERRONEOUS INPUT.#
10370 GOTO 10320
10380 X$=#PREPARED#
10390 GOTO 10410
10400 X$=#REQUESTED#
10410 IF V$=#NEW# THEN 10430
10420 IF V$=#OLD# THEN 11850
10430 F6=1
10440 F4=0
10450 GOTO 00290
10460 PRINT
10470 PRINT #MKS OR BRITISH UNITS#;
10480 INPUT W$
10490 IF W$=#MKS# THEN 00410
10500 IF W$=#BRITISH# THEN 00390
10510 GOTO 10470
10520 PRINT #CHEMICAL CODE#;
10530 INPUT W$
10540 GOSUB 07670
10550 IF F2=1 THEN 10580
10560 PRINT #ERRONEOUS INPUT.#
10570 GOTO 10520
10580 M1$=W$
10590 PRINT
10600 PRINT USING 10610,01$;
10610 :CARGO TEMP.. <≡≡≡≡≡≡≡≡≡≡≡
10620 GOTO 00650
```

FIGURE B-2 (continued)

```
10630 PRINT
10640 PRINT #TANK PRESSURE, ATM*S.#;
10650 GOTO 00800
10660 PRINT
10670 PRINT USING 10680,02$;
10680 :TANK CAPACITY, <==========================
10690 GOTO 00860
10700 PRINT
10710 PRINT USING 10720,03$;
10720 :TANK HEIGHT, <=======
10730 GOTO 00950
10740 PRINT
10750 PRINT #FRACTION FILLED#;
10760 INPUT W
10770 IF W<1.00  AND W>0.0 THEN 01040
10780 PRINT #ERRONEOUS INPUT.#
10790 GOTO 10750
10800 PRINT
10810 PRINT #HOLE DIAMETER#;
10820 : HOLE DIAMETER, <=======
10830 GOTO 01090
10840 PRINT
10850 PRINT #HOLE-CENTERLINE HEIGHT (OVER WATERLINE)#;
10860 GOTO 01260
10870 PRINT
10880 PRINT #HOLE-BOTTOM HEIGHT (OVER TANK BOTTOM)#;
10890 GOTO 01350
10900 PRINT #OPEN WATERS (1) OR RIVER/CHANNEL (2)#;
10910 INPUT W
10920 IF W=1 OR W=2 THEN 01450
10930 PRINT #ERRONEOUS INPUT.#
10940 GOTO 10900
10950 PRINT
10960 PRINT #WATER TEMP.#;
10970 GOTO 01550
10980 PRINT
10990 IF Z(2,10)=1 THEN 11160
11000 PRINT #RIVER WIDTH#;
11010 GOTO 01690
11020 PRINT
11030 PRINT #AVG. RIVER DEPTH#;
11040 GOTO 01810
11050 PRINT
11060 PRINT USING 11070,04$;
11070 :AVG. RIVER VELOCITY, <==================
11080 GOTO 01910
11090 PRINT
11100 PRINT #BANKS CODE(1,2, OR 3)#;
11110 INPUT W
11120 IF W=1 OR W=2 OR W=3 THEN 11150
11130 PRINT #ERRONEOUS INPUT.#
11140 GOTO 11100
11150 GOTO 02010
11160 PRINT #WIND SPEED, #;04$;
11170 GOTO 02130
11180 PRINT
11190 PRINT #DOWNWIND ANGLE(0=NORTH)#;
11200 INPUT W
11210 IF W>=0 AND W<360 GOTO 11240
11220 REM
11230 REM
11240 PRINT #ERRONEOUS INPUT.#
11250 GOTO 11190
11260 GOTO 02220
```

FIGURE B-2 (continued)

```
11270 PRINT
11280 PRINT #AIR TEMP.#;
11290 INPUT W
11300 Z(2,18)=W
11310 Z(1,18)=2054
11320 IF F1=1 THEN 11350
11330 Z(3,18)=W
11340 GOTO 11360
11350 Z(3,18)=(W-32)*5/9
11360 IF F4=1 THEN 06400
11370 PRINT
11380 PRINT #ATMOS. STABILITY(B,D OR F)#;
11390 INPUT W$
11400 IF W$=#B# OR W$=#D# OR W$=#F# THEN 11430
11410 PRINT #ERRONEOUS INPUT.#
11420 GOTO 11380
11430 GOTO 02270
11440 PRINT #LATITUDE: DEGREES FIRST.#
11450 GOTO 02390
11460 PRINT #LONGITUDE: DEGREES FIRST.#
11470 GOTO 02800
11480 PRINT #SPILL-SHORE SEPARATION(DOWNWIND DIRECTION)#;
11490 INPUT W
11500 Z(2,22)=W
11510 IF F4=1 THEN 06680
11520 PRINT
11530 PRINT #DAMAGE CODE(1,2,3 OR 4)#;
11540 GOTO 03170
11550 PRINT #GEOGRAPHIC CODE(4 DIGITS)#;
11560 GOTO 03560
11570 PRINT #SECONDARY FIRES(YES OR NO)#;
11580 INPUT W$
11590 IF W$=#YES# THEN 11630
11600 IF W$=#NO# THEN 11650
11610 PRINT #ERRONEOUS INPUT.#
11620 GOTO 11570
11630 Z(3,25)=1
11640 GOTO 11660
11650 Z(3,25)=0
11660 H5$=W$
11670 Z(1,25)=3004
11680 PRINT
11690 PRINT #FRACTION SHELTERED#;
11700 INPUT W
11710 IF W<1.0 AND W>0.0 THEN 11740
11720 PRINT #ERRONEOUS INPUT#
11730 GOTO 11690
11740 Z(2,26)=W
11750 Z(1,26)=5030
11760 Z(3,26)=W
11770 IF F4=1 THEN 06400
11780 PRINT
11790 PRINT #CHANGE THE DEFAULT TIME SEQUENCES(YES OR NO)#;
11800 INPUT W$
11810 B3$=W$
11820 F6=2
11830 IF W$=#NO# THEN 04200
11840 IF W$=#YES# THEN 03720
11850 PRINT #NAME OF FILE#;
11860 INPUT C$
11870 D=2
11880 IF C$=#STOP# THEN 13070
11890 IF LEN(C$)=6 THEN 11920
11900 PRINT #ERROR-CHECK FILE'S NAME OR TYPE STOP.#
11910 GOTO 11850
```

FIGURE B-2 (continued)

```
11920 FILE ≡D: ≠GET,×+D$
11930 PRINT
11940 PRINT ≠LOADING ≠;D$;≠...≠
11950 F6=2
11960 GOTO 09550
11970 REM ≠BRANCH TO BUILD A VM-ACCEPTABLE DATA FILE.≠
11980 D=4
11990 FILE ≡D=≠VMINPUT≠
12000 PRINT ≡D,N1$,N2$
12010 PRINT ≡D,≠  ≠
12020 PRINT ≡D,≠100I≠;M1$
12030 PRINT ≡D USING 12040,Z(1,4),Z(3,4)
12040 :≡≡≡≡ .≡≡≡≡¥¥¥¥
12050 PRINT ≡D USING 12060,Z(1,5),Z(3,5)
12060 :≡≡≡≡ ≡≡≡≡≡.≡
12070 PRINT ≡D USING 12080,Z(1,9),Z(3,9)
12080 :≡≡≡≡ ≡≡≡≡≡.≡
12090 PRINT ≡D USING 12100,Z(1,2),Z(3,2)
12100 :≡≡≡≡ ≡≡≡≡.≡≡
12110 PRINT ≡D USING 12120,Z(1,3),Z(3,3)
12120 :≡≡≡≡ .≡≡≡≡¥¥¥¥
12130 PRINT ≡D USING 12140,Z(1,135),Z(3,135)
12140 :≡≡≡≡ ≡.
12150 PRINT ≡D USING 12160,Z(1,6),Z(3,6)
12160 :≡≡≡≡ .≡≡≡≡¥¥¥¥
12170 PRINT ≡D USING 12180,Z(1,7),Z(3,7)
12180 :≡≡≡≡ .≡≡≡≡¥¥¥¥
12190 PRINT ≡D USING 12200,Z(1,137),Z(3,137)
12200 :≡≡≡≡ .≡≡≡≡¥¥¥¥
12210 PRINT ≡D USING 12220,Z(1,8),Z(3,8)
12220 :≡≡≡≡ .≡≡≡≡¥¥¥¥
12230 PRINT ≡D USING 12240,Z(1,16),Z(3,16)
12240 :≡≡≡≡ .≡≡≡≡¥¥¥¥
12250 PRINT ≡D USING 12260,Z(1,19),Z(3,19)
12260 :≡≡≡≡ ≡.
12270 PRINT ≡D USING 12280,Z(1,10),Z(3,10)
12280 :≡≡≡≡ ≡.
12290 IF Z(2,10)=1 THEN 12320
12300 PRINT ≡D USING 12310,Z(1,12),Z(3,12)
12310 :≡≡≡≡ .≡≡≡≡¥¥¥¥
12320 PRINT ≡D USING 12330,Z(1,138),Z(3,138)
12330 :≡≡≡≡ ≡.
12340 PRINT ≡D USING 12350,Z(1,11),Z(3,11)
12350 :≡≡≡≡ ≡≡≡.≡≡
12360 PRINT ≡D USING 12370,Z(1,139),Z(3,139)
12370 :≡≡≡≡ ≡≡≡.≡≡≡≡
12380 PRINT ≡D USING 12390,Z(1,101),Z(3,101)
12390 :≡≡≡≡ ≡.
12400 PRINT ≡D USING 12410,Z(1,102),Z(3,102)
12410 :≡≡≡≡ ≡.
12420 PRINT ≡D USING 12430,Z(1,140),Z(3,140)
12430 :≡≡≡≡ ≡≡≡≡.
12440 PRINT ≡D USING 12450,Z(1,103),Z(3,103)
12450 :≡≡≡≡ ≡≡≡≡.≡≡
12460 PRINT ≡D USING 12470,Z(1,141),Z(3,141)
12470 :≡≡≡≡ .≡≡≡≡¥¥¥¥
12480 IF Z(2,10)=1 THEN 12530
12490 PRINT ≡D USING 12500,Z(1,13),Z(3,13)
12500 :≡≡≡≡ ≡≡≡≡.
12510 PRINT ≡D USING 12520,Z(1,104),Z(3,104)
12520 :≡≡≡≡ .≡≡≡≡¥¥¥¥
12530 PRINT ≡D USING 12540,Z(1,142),Z(3,142)
12540 :≡≡≡≡ ≡.≡
12550 IF Z(2,10)=1 THEN 12600
12560 PRINT ≡D USING 12570,Z(1,14),Z(3,14)
12570 :≡≡≡≡ ≡≡≡≡.≡
12580 PRINT ≡D USING 12590,Z(1,15),Z(3,15)
12590 :≡≡≡≡ ≡.
12600 PRINT ≡D USING 12610,Z(1,18),Z(3,18)
12610 :≡≡≡≡ ≡≡≡≡.≡≡
```

FIGURE B-2 (continued)

```
12620 PRINT ≡0 USING 12630,Z(1,17),Z(3,17)
12630 :≡≡≡≡ ≡≡≡.≡≡
12640 IF MS$=#YES# AND G$<>#SFBLANK# THEN 12660
12650 G$=#SFBLANK#
12660 PRINT ≡0 USING 12670,Z(1,25),Z(3,25)
12670 :≡≡≡≡ ≡.
12680 PRINT ≡0 USING 12690,Z(1,143),Z(3,143)
12690 :≡≡≡≡ ≡.
12700 PRINT ≡0 USING 12710,Z(1,23),Z(3,23)
12710 :≡≡≡≡ ≡.
12720 PRINT ≡0 USING 12730,Z(1,105),Z(3,105)
12730 :≡≡≡≡ ≡.
12740 IF Z(2,23)=4 THEN 12770
12750 PRINT ≡0 USING 12760,Z(1,106),Z(3,106)
12760 :≡≡≡≡ ≡.
12770 PRINT ≡0 USING 12780,Z(1,147),Z(3,147)
12780 :≡≡≡≡ ≡≡≡.
12790 PRINT ≡0 USING 12800,Z(1,146),Z(3,146)
12800 :≡≡≡≡  ≡.
12810 IF Z(3,155)=999 THEN 12840
12820 PRINT ≡0 USING 12830,Z(1,155),Z(3,155)
12830 :≡≡≡≡ ≡≡≡≡.≡
12840 FOR K=148 TO 154
12850 PRINT ≡0 USING 12860,Z(1,K),Z(3,K)
12860 :≡≡≡≡ ≡≡≡≡.≡≡≡
12870 NEXT K
12880 PRINT ≡0 USING 12890,Z(1,26),Z(3,26)
12890 :≡≡≡≡ ≡.≡≡
12900 FOR K=27 TO 35
12910 PRINT ≡0 USING 12920,Z(1,K),Z(3,K)
12920 :≡≡≡≡ ≡≡≡≡.
12930 NEXT K
12940 PRINT ≡0 USING 12950,Z(1,20),L$(1)
12950 :≡≡≡≡ ≡≡≡≡≡≡≡≡≡
12960 PRINT ≡0 USING 12970,Z(1,21),L$(2)
12970 :≡≡≡≡ ≡≡≡≡≡≡≡≡≡
12980 PRINT ≡0
12990 CLOSE ≡0
13000 FILE ≡15: #GET,#,F$
13010 CLOSE ≡15
13020 IF G$=#SFBLANK# THEN 13050
13030 FILE ≡16: #GET,#,G$
13040 CLOSE ≡16
13050 PRINT
13060 PRINT #THANK YOU FOR USING THE UIM.#
13070 STOP
13080 IF Z(2,24)<>3611 THEN 13120
13090 F$=#GEONY4#
13100 G$=#SECNY4#
13110 GOTO 13320
13120 IF Z(2,24)<>3612 THEN 13160
13130 F$=#GEONY8#
13140 G$=#SFBLANK#
13150 GOTO 13320
13160 IF Z(2,24)<>1611 THEN 13200
13170 F$=#GEOLA1#
13180 G$=#SFBLANK#
13190 GOTO 13320
13200 IF Z(2,24)<>1612 THEN 13240
13210 F$=#GEOLA2#
13220 G$=#SFBLANK#
13230 GOTO 13320
13240 IF Z(2,24)<> 3211 THEN 13280
13250 F$=#GEONC1#
13260 G$=#SECFNE#
13270 GOTO 13320
13280 PRINT #THIS GEOGRAPHIC FILE DOES NOT EXIST.#
13290 PRINT #PLEASE RE-ENTER THIS VALUE, OR TYPE#
13300 PRINT #THE WORD STOP TO END THE PROGRAM.#
13310 Q4=1
13320 RETURN
```

FIGURE B-2 (concluded)

```
00010 BASE 1
00020 DIM Z(3,200)
00030 DIM C3(27,18)
00040 GOSUB 11020
00050 F4=0
00060 F5=0
00070 M5$=≠NO≠
00080 Z(1,25)=3004
00090 F8=0
00100 PRINT ≠PLEASE ENTER YOUR LAST NAME AND THE TITLE OF ≠
00110 PRINT ≠THIS SPILL SIMULATION IN THAT ORDER--≠
00120 PRINT
00130 PRINT ≠EXAMPLE-- SMITH/LNG SPILL' NEW YORK≠
00140 INPUT N1$
00150 PRINT
00160 PRINT
00170 N2$=DAT$
00180 PRINT ≠WELCOME TO THE UIM.≠
00190 PRINT ≠THIS PROGRAM IS USED TO ACCESS THE VULNERABILITY MODEL.≠
00200 PRINT
00210 K$=≠YES≠
00220 PRINT ≠THE VM CAN SIMULATE CHEMICAL SPILLS AND THEIR POSSIBLE≠
00230 PRINT ≠CONSEQUENCES AT THE FOLLOWING PORTS:≠
00240 PRINT
00250 PRINT ≠    LOS ANGELES≠
00260 PRINT ≠    NEW ORLEANS≠
00270 PRINT ≠    NEW YORK≠
00280 PRINT
00290 PRINT ≠IF YOU ARE INTERESTED IN SPILLS AT OTHER LOCATIONS,≠
00300 PRINT ≠ASK THE VM PROJECT OFFICER FOR ASSISTANCE.≠
00310 PRINT
00320 PRINT ≠TO RUN A SPILL SIMULATION YOU MUST EITHER PREPARE A NEW≠
00330 PRINT ≠INPUT FILE (DATA LIST) OR USE A PREVIOUSLY PREPARED INPUT FILE.≠
00340 PRINT ≠ENTER THE WORD OLD IF YOU WISH TO USE AND EDIT AN OLD≠
00350 PRINT ≠INPUT FILE. OTHERWISE, ENTER THE WORD NEW AFTER THE≠
00360 PRINT ≠QUESTION MARK AND DEPRESS THE CARRIAGE RETURN KEY.≠
00370 INPUT V$
00380 IF V$=≠OLD≠ THEN 00410
00390 X$=≠PREPARED≠
00400 GOTO 00420
00410 X$=≠REQUESTED≠
00420 IF V$ = ≠OLD≠ OR V$=≠NEW≠ THEN 00460
00430 PRINT ≠INPUT MUST BE EITHER NEW OR OLD≠
00440 PRINT ≠PLEASE REENTER≠
00450 GOTO 00370
00460 IF V$=≠OLD≠ THEN 17850
00470 GOSUB 17740
00480 PRINT
00490 B3=0
00500 PRINT ≠TO PREPARE YOUR INPUT FILE, ENTER THE APPROPRIATE INFOR-≠
00510 PRINT ≠MATION FOR EACH SET OF QUESTIONS OR DATA REQUEST BELOW.≠
00520 PRINT ≠FOR EACH SET OF QUESTIONS YOU WILL BE GIVEN TWO OPTIONS:≠
00530 PRINT
00540 PRINT ≠     OPTION 1: IF YOU NEED INSTRUCTIONS OR ADDITIONAL INFOR-≠
00550 PRINT ≠     MATION TO HELP YOU PREPARE THE INPUTS, ENTER THE WORD≠
00560 PRINT ≠     INFO≠
00570 PRINT
00580 PRINT ≠     OPTION 2: IF YOU DO NOT NEED INSTRUCTIONS AND YOU ARE≠
00590 PRINT ≠     PREPARED TO PROVIDE THE DATA REQUESTED, ENTER THE WORD≠
00600 PRINT ≠     INPUT≠
00610 PRINT
00620 PRINT ≠IF YOU WISH TO CHANGE ANY OF THE VALUES AFTER YOU HAVE≠
00630 PRINT ≠ENTERED THEM, WAIT UNTIL YOU HAVE COMPLETED THE ENTIRE≠
00640 PRINT ≠INPUT FILE. YOU WILL THEN BE GIVEN THE OPPORTUNITY TO≠
00650 PRINT ≠EDIT AND CORRECT YOUR INPUT FILE.≠
00660 PRINT
```

FIGURE B-3. Program UIML

```
00670 PRINT #BE SURE TO ENTER THE DATA IN THE PROPER FORMAT AND IN THE#
00680 PRINT #PROPER UNITS..WORD ENTRIES NEED NOT BE ENCLOSED IN QUOTES.#
00690 PRINT #NUMBERS MUST BE ENTERED IN DECIMAL FORMAT. SCIENTIFIC#
00700 PRINT #OR EXPONENTIAL NOTATION IS NOT ALLOWED.#
00710 PRINT
00720 PRINT #YOU CAN ENTER QUANTITATIVE DATA IN EITHER MKS (METER-KILOGRAM-SECOND)#
00730 PRINT #OR BRITISH UNITS, BUT YOU CANNOT USE BOTH IN ONE INPUT FILE.#
00740 PRINT #WHICH DO YOU PREFER.#
00750 PRINT #ANSWER EITHER MKS OR BRITISH.#
00760 INPUT W$
00770 IF W$ =#MKS# OR W$=#BRITISH# THEN 00810
00780 PRINT #YOUR ANSWER MUST BE EITHER MKS OR BRITISH.#
00790 PRINT #PLEASE RETYPE YOUR ANSWER#
00800 GOTO 00760
00810 IF W$=#MKS# THEN 00840
00820 F1=1
00830 GO TO 00850
00840 F1=2
00850 Z(1,120)=20
00860 Z(2,120)=F1
00870 PRINT
00880 PRINT
00890 PRINT #THE FIRST THREE INPUTS REQUIRED DESCRIBE THE CHARACTERISTICS#
00900 PRINT #OF THE CHEMICAL CARGO PRIOR TO THE SPILL. THESE ARE THE#
00910 PRINT #CHEMICAL NAME, THE TEMPERATURE AND THE PRESSURE OF THE#
00920 PRINT #CARGO WITHIN THE TANK IN ATMOSPHERES. FOR THE NAME OF#
00930 PRINT #THE CHEMICAL , YOU WILL NEED TO SPECIFY THE THREE LETTER#
00940 PRINT #CHEMICAL CODE. #
00950 PRINT
00960 PRINT #REQUEST INFO IF YOU DO NOT KNOW THE CODE OR NEED INFOR-#
00970 PRINT #MATION ON CARGO TEMPERATURES AND PRESSURES. ENTER EITHER#
00980 PRINT #INFO OR INPUT.#
00990 INPUT W$
01000 IF W$=#INFO# OR W$=#INPUT# THEN 01040
01010 PRINT #YOUR ANSWER MUST BE EITHER INFO OR INPUT#
01020 PRINT #PLEASE RETYPE YOUR ANSWER#
01030 GOTO 00990
01040 IF W$=#INPUT# THEN 01060
01050 GOSUB 13960
01060 IF F1=1 THEN 01120
01070 O1$=#CELSIUS.#
01080 O2$=#CUBIC METERS.#
01090 O3$=#METERS.#
01100 O4$=#METERS PER SECOND.#
01110 GOTO 01160
01120 O1$=#FAHRENHEIT.#
01130 O2$=#THOUSANDS OF GALLONS.#
01140 O3$=#FEET.#
01150 O4$=#FEET PER SECOND.#
01160 IF F5=1 THEN 18090
01170 PRINT #ENTER THE THREE LETTER CODE OF THE CHEMICAL INVOLVED#
01180 PRINT #IN THE SPILL#
01190 INPUT W$
01200 GOSUB 11930
01210 IF F2=1 THEN 01300
01220 PRINT #INPUT MUST BE A VALID CHEMICAL CODE#
01230 PRINT #IF YOU NEED INFORMATION PLEASE TYPE INFO OTHERWISE#
01240 PRINT #PLEASE RE-ENTER THE APPROPRIATE CHEMICAL CODE.#
01250 INPUT W$
01260 IF W$=#INFO# THEN 01280
01270 GOTO 01200
01280 GOSUB 13960
01290 GOTO 01170
01300 M1$=W$
01310 PRINT #ENTER THE TEMPERATURE OF THE CARGO PRIOR TO THE SPILL#
01320 PRINT USING 01330,O1$
01330 :IN DEGREES <''''''''''''
```

FIGURE B-3 (continued)

```
01340 INPUT W
01350 Z(2,2)=W
01360 Z(1,2)=2004
01370 IF F1=2 THEN 01400
01380 Z(3,2)=(W-32)*(5/9)
01390 GOTO 01410
01400 Z(3,2)=W
01410 Z(1,103)=2036
01420 IF W<-200 OR W>300 THEN 01460
01430 Z(3,103)=Z(3,2)
01440 IF F4=1 THEN 09740
01450 GOTO 01490
01460 PRINT "THIS TEMPERATURE IS BEYOND THE RANGE OF THE VM."
01470 PRINT "PLEASE ENTER ANOTHER VALUE OR TYPE STOP---"
01480 GOTO 01310
01490 PRINT "ENTER THE TANK PRESSURE PRIOR TO THE RUPTURE IN ATMOSPHERES"
01500 INPUT W
01510 Z(2,3)=W
01520 Z(1,3)=2005
01530 Z(3,3)=W*1000000
01540 IF F4=1 THEN 09740
01550 PRINT
01560 PRINT
01570 PRINT "THE NEXT THREE INPUTS REQUESTED ARE THE CAPACITY, HEIGHT, AND"
01580 PRINT "FRACTION FILLED OF THE RUPTURED TANK(S)."
01590 PRINT "ENTER EITHER INFO OR INPUT"
01600 INPUT W$
01610 IF W$="INFO" OR W$="INPUT" THEN 01650
01620 PRINT "YOUR ANSWER MUST BE EITHER INPUT OR INFO"
01630 PRINT "PLEASE RETYPE YOUR ANSWER"
01640 GOTO 01600
01650 IF W$="INPUT" THEN 01670
01660 GOSUB 11320
01670 PRINT USING 01680,O2$
01680 :ENTER THE CAPACITY OF THE TANK IN UNITS OF <''''''''''''''''''''''
01690 INPUT W
01700 Z(2,4)=W
01710 Z(1,4)=2001
01720 IF F1=2 THEN 01750
01730 Z(3,4)=W*3785000
01740 GOTO 01760
01750 Z(3,4)=W*1000000
01760 IF F4=1 THEN 01950
01770 PRINT USING 01780,O3$
01780 :ENTER THE HEIGHT OF THE TANK IN <'''''''
01790 INPUT W
01800 Z(2,5)=W
01810 Z(1,5)=2002
01820 IF F1=2 THEN 01850
01830 Z(3,5)=W*30.48
01840 GOTO 01860
01850 Z(3,5)=W*100
01860 IF F4=1 THEN 09740
01870 PRINT "ENTER THE FRACTION OF THE TANK FILLED."
01880 INPUT W
01890 IF W<=1.00 THEN 01930
01900 PRINT "YOUR ANSWER MUST BE LESS THEN 1.00:"
01910 PRINT "PLEASE RETYPE YOUR ANSWER."
01920 GOTO 01880
01930 Z(2,6)=W
01940 Z(1,6)=2007
01950 Z(3,6)=Z(3,136)*Z(3,4)*Z(2,6)
01960 IF F4=1 THEN 09740
01970 PRINT
01980 PRINT "THREE INPUTS ARE REQUIRED TO DESCRIBE THE SIZE AND LOCATION"
01990 PRINT "OF THE RUPTURE. THESE ARE THE DIAMETER OF THE HOLE, THE"
02000 PRINT "HEIGHT OF THE HOLE'S CENTERLINE ABOVE THE WATERLINE"
02010 PRINT "AND THE HEIGHT OF THE BOTTOM OF THE HOLE ABOVE THE"
02020 PRINT "BOTTOM OF THE TANK. ENTER EITHER INFO OR INPUT."
02030 INPUT W$
```

FIGURE B-3 (continued)

```
02040 IF W$=≠INPUT≠ OR W$=≠INFO≠ THEN 02080
02050 PRINT ≠YOUR ANSWER MUST BE EITHER INFO OR INPUT≠
02060 PRINT ≠PLEASE RETYPE YOUR ANSWER≠
02070 GOTO 02030
02080 IF W$=≠INPUT≠ THEN 02100
02090 GOSUB 12440
02100 PRINT USING 02110,03$
02110 :ENTER THE DIAMETER OF THE HOLE IN <=======
02120 INPUT W
02130 IF W>0 THEN 02160
02140 PRINT ≠ERROR-- HOLE SIZE MUST BE A POSITIVE, NON-ZERO NUMBER.≠
02150 GOTO 02100
02160 Z(2,7)=W
02170 Z(1,7)=2008
02180 IF F1=1 THEN 02210
02190 Z(3,7)=W*100
02200 GOTO 02220
02210 Z(3,7)=W*30.48
02220 Z(1,102)=2029
02230 IF Z(3,7)>100 THEN 02260
02240 Z(3,102)=1
02250 GOTO 02270
02260 Z(3,102)=0
02270 IF F4=1 THEN 09740
02280 PRINT ≠ENTER THE HEIGHT OF THE HOLE'S CENTERLINE ABOVE THE≠
02290 PRINT USING 02300,03$
02300 :WATERLINE IN <=======
02310 INPUT W
02320 Z(2,8)=W
02330 Z(1,8)=2015
02340 IF F1=1 THEN 02370
02350 Z(3,8)=W*100
02360 GOTO 02380
02370 Z(3,8)=W*30.48
02380 IF F4=1 THEN 09740
02390 PRINT ≠ENTER THE HEIGHT OF THE BOTTOM OF THE HOLE ABOVE THE≠
02400 PRINT USING 02410,03$
02410 :BOTTOM OF THE TANK IN <=======
02420 INPUT W
02430 Z(2,9)=W
02440 Z(1,9)=2003
02450 IF F1=2 THEN 02480
02460 Z(3,9)=W*30.48
02470 GOTO 02490
02480 Z(3,9)=W*100
02490 PRINT
02500 IF F4=1 THEN 09740
02510 PRINT
02520 PRINT
02530 PRINT
02540 PRINT ≠ THE NEXT SERIES OF INPUTS ARE NEEDED BY THE VM TO COMPUTE≠
02550 PRINT ≠THE SPREADING, MIXING, AND EVAPORATION OF THE SPILLED CARGO.≠
02560 PRINT ≠FIRST IS NEEDED THE TYPE OF WATER UPON WHICH THE SPILL≠
02570 PRINT ≠OCCURS AND THE WATER TEMPERATURE. IF IN A CHANNEL OR≠
02580 PRINT ≠RIVER, INPUTS ARE THEN REQUIRED FOR CHANNEL WIDTH, DEPTH,≠
02590 PRINT ≠VELOCITY, AND ROUGHNESS OF THE BANKS. IF YOU REQUEST
02600 PRINT ≠INFO, MATERIAL WILL BE SUPPLIED ON REPRESENTATIVE VALUES≠
02610 PRINT ≠OF THESE VARIABLES FOR RELEVANT U.S. PORTS.≠
02620 PRINT ≠ENTER EITHER INFO OR INPUT≠
02630 INPUT W$
02640 IF W$=≠INFO≠ OR W$=≠INPUT≠ THEN 02690
02650 PRINT ≠YOUR ANSWER MUST BE EITHER INFO OR INPUT≠
02660 PRINT ≠PLEASE RETYPE YOUR ANSWER≠
02670 GOTO 02630
```

FIGURE B-3 (continued)

```
02680 IF K$<>#YES# THEN 07900
02690 IF W$=#INPUT# THEN 02710
02700 GOSUB 14580
02710 PRINT #DOES THE SPILL OCCUR IN RELATIVELY OPEN WATERS(AT SEA OR#
02720 PRINT #IN THE PORT) OR DOES IT OCCUR IN A CHANNEL OR RIVER,#
02730 PRINT #ENTER 1 FOR OPEN WATERS AND 2 FOR CHANNEL OR RIVER,#
02740 INPUT W
02750 IF W=1 OR W=2 THEN 02790
02760 PRINT #YOUR ANSWER CAN ONLY BE 1 OR 2#
02770 PRINT #PLEASE RETYPE YOUR ANSWER#
02780 GOTO 02740
02790 Z(2,10)=W
02800 Z(1,101)=2028
02810 Z(3,101)=W
02820 Z(1,10)=2018
02830 IF W=1 THEN 02860
02840 Z(3,10)=1
02850 GOTO 02870
02860 Z(3,10)=2
02870 IF F4=1 THEN 09920
02880 PRINT USING 02890,01$
02890 :ENTER THE WATER TEMPERATURE IN DEGREES <=============
02900 INPUT W
02910 Z(2,11)=W
02920 Z(1,11)=2023
02930 IF F1=1 THEN 02990
02940 IF W>-5 AND W<50 THEN 02970
02950 PRINT #ERROR-- TEMPERATURE IS OUT OF RANGE,#
02960 GOTO 02880
02970 Z(3,11)=W
02980 GOTO 03020
02990 Z(3,11)=(W-32)*(5/9)
03000 W=Z(3,11)
03010 GOTO 02940
03020 IF F4>0 THEN 09740
03030 IF Z(2,10)=1 THEN 03550
03040 PRINT USING 03050,03$
03050 :ENTER THE WIDTH OF THE CHANNEL OR RIVER IN <=======
03060 INPUT W
03070 Z(2,12)=W
03080 Z(1,12)=2020
03090 IF F1=1 THEN 03120
03100 Z(3,12)=W*100
03110 GOTO 03130
03120 Z(3,12)=W*30.48
03130 Z(1,104)=2045
03140 Z(3,104)=Z(3,12)
03150 IF F4=2 THEN 09740
03160 PRINT USING 03170,03$
03170 :ENTER THE AVERAGE DEPTH OF THE RIVER IN <=======
03180 INPUT W
03190 Z(2,13)=W
03200 Z(1,13)=2044
03210 IF F1=1 THEN 03240
03220 Z(3,13)=W*100
03230 GOTO 03250
03240 Z(3,13)=W*30.48
03250 IF F4=2 THEN 09740
03260 PRINT #ENTER THE AVERAGE VELOCITY OF THE RIVER#
03270 PRINT USING 03280,04$
03280 :FLOW IN <=================
03290 INPUT W
03300 Z(2,14)=W
03310 Z(1,14)=2047
03320 IF F1=1 THEN 03350
03330 Z(3,14)=W*100
03340 GOTO 03360
```

FIGURE B-3 (continued)

```
03350 Z(3,14)=W*30.48
03360 IF F4=2 THEN 09740
03370 PRINT #DOES THE RIVER HAVE CLEAN STRAIGHT BANKS(1)#
03380 PRINT #MODERATELY ROUGH, STONEY BANKS(2)#
03390 PRINT #OR VERY SLUGGISH AND WEEDY BANKS(3)#
03400 PRINT #ENTER 1, 2, OR 3#
03410 INPUT W
03420 IF W=1 OR W=2 OR W=3 THEN 03460
03430 PRINT #YOUR ANSWER MUST 1, 2, OR 3#
03440 PRINT #PLEASE RETYPE YOUR ANSWER#
03450 GOTO 03410
03460 Z(2,15)=W
03470 Z(1,15)=2052
03480 IF W=2 OR W=3 THEN 03510
03490 Z(3,15)=.03
03500 GOTO 03550
03510 IF W=3 THEN 03540
03520 Z(3,15)=.05
03530 GOTO 03550
03540 Z(3,15)=.10
03550 PRINT
03560 IF F4=2 OR F4=1 THEN 09740
03570 PRINT
03580 PRINT
03590 PRINT #THE NEXT FOUR INPUTS ARE NEEDED TO DETERMINE THE#
03600 PRINT #VAPOR CLOUD DISPERSION. THESE ARE THE WIND SPEED,#
03610 PRINT #WIND DIRECTION, AIR TEMPERATURE, AND ATMOSPHERIC#
03620 PRINT #STABILITY.#
03630 PRINT #ENTER EITHER INFO OR INPUT#
03640 INPUT W$
03650 IF W$=#INFO# OR W$=#INPUT# THEN 03690
03660 PRINT #YOUR ANSWER MUST BE EITHER INFO OR INPUT.#
03670 PRINT #PLEASE RETYPE YOUR ANSWER.#
03680 GOTO 03640
03690 IF W$=#INPUT# THEN 03710
03700 GOSUB 13180
03710 PRINT USING 03720,04$
03720 :ENTER THE AVERAGE WIND SPEED IN <=================
03730 INPUT W
03740 Z(2,16)=W
03750 Z(1,16)=2016
03760 IF F1=1 THEN 03790
03770 Z(3,16)=W*100
03780 GOTO 03800
03790 Z(3,16)=W*30.48
03800 IF F4=1 THEN 10020
03810 PRINT #ENTER THE ANGLE BETWEEN THE DOWNWIND DIRECTION AND#
03820 PRINT #NORTH, MEASURED IN DEGREES CLOCKWISE FROM NORTH.#
03830 INPUT W
03840 IF W>=0 AND W<360 THEN 03880
03850 PRINT #YOUR ANSWER MUST BE LESS THAN 360 DEGREES.#
03860 PRINT #PLEASE RETYPE YOUR ANSWER.#
03870 GOTO 03830
03880 Z(2,17)=W
03890 Z(1,17)=2058
03900 Z(3,17)=.
03910 IF F4=1 THEN 04740
03920 PRINT USING 03930,01$
03930 :ENTER THE AIR TEMPERATURE IN DEGREES <===============
03940 INPUT W
03950 Z(2,18)=.
03960 Z(1,18)=2054
03970 IF F1=1 THEN 04030
03980 IF W<50 AND W>=41 THEN 04010
03990 PRINT #ERROR-- TEMPERATURE IS OUT OF RANGE.#
04000 GOTO 03920
```

FIGURE B-3 (continued)

```
04010 Z(3,18)=W
04020 GOTO 04060
04030 Z(3,18)=(W-32)*(5/9)
04040 W=Z(3,18)
04050 GOTO 03980
04060 IF F4=1 THEN 09740
04070 PRINT #ENTER THE ONE-LETTER CODE FOR THE PASQUILL-GIFFORD#
04080 PRINT #ATMOSPHERIC STABILITY CLASS: B = UNSTABLE,#
04090 PRINT #C=NEUTRAL, AND F=HIGHLY STABLE.#
04100 PRINT #ENTER B,D, OR F.#
04110 INPUT W$
04120 IF W$=#B# OR W$=#D# OR W$=#F# THEN 04160
04130 PRINT #YOUR ANSWER MUST BE EITHER B, D, OR F.#
04140 PRINT #PLEASE RETYPE YOUR ANSWER#
04150 GOTO 04110
04160 Z(1,19)=2017
04170 M9$=W$
04180 IF W$=#B# OR W$=#D# THEN 04210
04190 Z(3,19)=6
04200 GOTO 04250
04210 IF W$=#B# THEN 04240
04220 Z(3,19)=4
04230 GOTO 04250
04240 Z(3,19)=2
04250 PRINT
04260 IF F4=1 THEN 09740
04270 PRINT
04280 PRINT #THE NEXT THREE INPUTS DESCRIBE THE POSITION OF THE SPILL:#
04290 PRINT #I.E., LATITUDE, LONGITUDE, AND WINDWARD DISTANCE FROM THE#
04300 PRINT #SHORE. ENTER INFO OR INPUT.#
04310 INPUT W$
04320 IF W$=#INPUT# OR W$=#INFO# THEN 04360
04330 PRINT #YOUR ANSWER MUST BE EITHER INPUT OR INFO.#
04340 PRINT #PLEASE RETYPE YOUR ANSWER.#
04350 GOTO 04310
04360 IF W$=#INPUT# THEN 04380
04370 GOSUB 14910
04380 PRINT
04390 PRINT
04400 PRINT #ENTER THE LATITUDE OF THE SPILL IN DEGREES, MINUTES,#
04410 PRINT #AND SECONDS NORTH OF THE EQUATOR.#
04420 PRINT
04430 PRINT #ENTER THE DEGREES FIRST#
04440 INPUT W
04450 W=INT(W)
04460 IF W <=89 THEN 04500
04470 PRINT #DEGREES ENTRY FOR LATITUDE MUST BE LESS THAN 90.#
04480 PRINT #PLEASE RETYPE YOUR ANSWER.#
04490 GOTO 04430
04500 L1$=STR$(W)
04510 IF LEN(L1$)=2 THEN 04530
04520 L1$=#0#+L1$
04530 PRINT #NOW ENTER THE MINUTES.#
04540 INPUT W
04550 W=INT(W)
04560 IF W < 60 THEN 04600
04570 PRINT #MINUTES ENTRY MUST ALWAYS BE LESS THAN 60.#
04580 PRINT #PLEASE RETYPE YOUR ANSWER.#
04590 GOTO 04530
04600 L2$=STR$(W)
04610 IF LEN(L2$)=2 THEN 04630
04620 L2$=#0#+L2$
04630 PRINT #NOW ENTER THE SECONDS.#
04640 INPUT W
04650 W=INT(W)
04660 IF W<>0 THEN 04690
04670 L3$=#00#
04680 GOTO 04770
```

FIGURE B-3 (continued)

```
04690 IF W < 60 THEN 04730
04700 PRINT #SECONDS ENTRY MUST ALWAYS BE LESS THAN 60.#
04710 PRINT #PLEASE RETYPE YOUR ANSWER.#
04720 GOTO 04630
04730 W=INT(W)
04740 L3$=STR$(W)
04750 IF W>=10 THEN 04770
04760 L3$=#0#+L3$
04770 L7$=#.#
04780 L$(1)=L1$+L2$+L3$+L7$
04790 Z(1,20)=6010
04800 PRINT
04810 IF F4=1 THEN 09740
04820 PRINT #ENTER THE LONGITUDE OF THE SPILL IN DEGREES, MINUTES,#
04830 PRINT #AND SECONDS WEST OF GREENWICH.#
04840 PRINT #ENTER THE DEGREES FIRST.#
04850 INPUT W
04860 W=INT(W)
04870 IF W<180 THEN 04910
04880 PRINT #DEGREES ENTRY FOR LONGITUDE MUST BE LESS THAN 180.#
04890 PRINT #PLEASE RETYPE YOUR ANSWER.#
04900 GOTO 04840
04910 L4$=STR$(W)
04920 IF LEN(L4$)=3 THEN 04960
04930 L4$=#0#+L4$
04940 IF LEN(L4$)=3 THEN 04960
04950 L4$=#0#+L4$
04960 PRINT #NOW ENTER THE MINUTES.#
04970 INPUT W
04980 W=INT(W)
04990 IF W < 60 THEN 05030
05000 PRINT #MINUTES ENTRY MUST ALWAYS BE LESS THAN 60#
05010 PRINT #PLEASE RETYPE YOUR ANSWER.#
05020 GOTO 04960
05030 L5$=STR$(W)
05040 IF LEN(L5$)=2 THEN 05060
05050 L5$=#0#+L5$
05060 PRINT #NOW ENTER THE SECONDS.#
05070 INPUT W
05080 IF W < 60 THEN 05120
05090 PRINT #SECONDS ENTRY MUST BE LESS THAN 60.#
05100 PRINT #PLEASE RETYPE YOUR ANSWER.#
05110 GOTO 05060
05120 W=ROF(W)
05130 W=INT(W)
05140 L6$=STR$(W)
05150 L7$=#.#
05160 IF W>=10 THEN 05180
05170 L6$=#0#+L6$
05180 L$(2)=L4$+L5$+L6$+L7$
05190 Z(1,21)=6011
05200 IF F4=1 THEN 09740
05210 PRINT
05220 PRINT #ENTER THE DISTANCE FROM THE SPILL TO THE SHORE ALONG#
05230 PRINT USING 05240,03$
05240 :THE DIRECTION OF THE WIND IN <############
05250 INPUT W
05260 Z(2,22)=W
05270 REM #CALC TIME FROM THIS W#
05280 PRINT
05290 IF F4=1 THEN 10020
05300 PRINT
05310 PRINT #THE NEXT INPUT WILL SPECIFY THE TYPE OF DAMAGE YOU#
05320 PRINT #WANT COMPUTED FOR THE GEOGRAPHICAL AREA WITHIN WHICH YOU#
05330 PRINT #WANT THE DAMAGE COMPUTED.#
05340 PRINT #ENTER EITHER INFO OR INPUT.#
05350 INPUT W$
```

FIGURE B-3 (continued)

```
05360 IF W$=≠INPUT≠ OR W$=≠INFO≠ THEN 05400
05370 PRINT ≠YOUR ANSWER MUST BE EITHER INPUT OR INFO.≠
05380 PRINT ≠PLEASE RETYPE YOUR ANSWER.≠
05390 GOTO 05350
05400 IF W$=≠INPUT≠ THEN 05420
05410 GOSUB 15200
05420 PRINT
05430 PRINT ≠      THE CODES FOR THE TYPES OF DAMAGE THAT CAN BE≠
05440 PRINT ≠COMPUTED BY THE VM ARE THE FOLLOWING==≠
05450 PRINT
05460 PRINT ≠      1 = TOXIC DAMAGE≠
05470 PRINT
05480 PRINT ≠      2 = FIRE DAMAGE FROM POOL BURNING (DUE TO BURNING≠
05490 PRINT ≠          OF SPILLED LIQUID ON THE WATER)≠
05500 PRINT
05510 PRINT ≠      3 = FIRE DAMAGE FROM FIREBALL (DUE TO RAPID≠
05520 PRINT ≠          COMBUSTION OF LIQUID-VAPOR MIXTURE)≠
05530 PRINT
05540 PRINT ≠      4 = FIRE DAMAGE FROM FLASH FIRE (DUE TO BURNING OF≠
05550 PRINT ≠          DISPERSED VAPOR CLOUD) DAMAGE FROM EXPLOSION≠
05560 PRINT ≠          OF THE VAPOR CLOUD IS ALSO COMPUTED WHEN THIS OPTION≠
05570 PRINT ≠          IS SELECTED≠
05580 PRINT
05590 PRINT ≠ENTER THE NUMERIC CODE FOR THE TYPE OF DAMAGE YOU ARE≠
05600 PRINT ≠INTERESTED IN. ONLY ONE CODE CAN BE ENTERED FOR ANY≠
05610 PRINT ≠ONE RUN.≠
05620 INPUT W
05630 IF W=1 OR W=2 OR W=3 OR W=4 THEN 05670
05640 PRINT ≠ YOUR ANSWER MUST BE 1, 2, 3, OR 4.≠
05650 PRINT ≠PLEASE RETYPE YOUR ANSWER.≠
05660 GOTO 05620
05670 Z(1,23)=5003
05680 Z(1,105)=5004
05690 Z(1,106)=5006
05700 Z(2,23)=W
05710 IF Z(2,23)=1 OR Z(2,23)=4 THEN 05740
05720 Z(3,106)=Z(2,23)
05730 GOTO 05750
05740 Z(3,106)=0
05750 IF Z(3,144)=1 AND Z(3,145)=1 THEN 05820
05760 IF Z(3,145)=1 THEN 05820
05770 IF Z(2,23)=2 OR Z(2,23)=3 OR Z(2,23)=4 THEN 05820
05780 PRINT ≠THE CHEMICAL SPILLED IS NOT SUFFICIENTLY TOXIC TO CAUSE≠
05790 PRINT ≠SIGNIFICANT TOXIC DAMAGE. A RUN REQUESTING FIRE DAMAGE IS≠
05800 PRINT ≠RECOMMENDED.≠
05810 GOTO 05420
05820 IF Z(2,23)=1 THEN 05850
05830 Z(3,23)=1
05840 GOTO 05860
05850 Z(3,23)=0
05860 REM ≠THIS TO EDIT TYPE OF CHEMICAL≠
05870 IF Z(3,144)=1 AND Z(3,145)=1 THEN 05930
05880 IF Z(3,144)=1 THEN 05930
05890 IF Z(2,23)=1 THEN 05930
05900 PRINT ≠THE CHEMICAL SPILLED IS NOT FLAMMABLE, HENCE THERE CAN BE≠
05910 PRINT ≠NO FIRE DAMAGE. A RUN REQUESTING TOXIC DAMAGE IS RECOMMENDED.≠
05920 GOTO 05420
05930 IF Z(2,23)=1 THEN 05960
05940 Z(3,105)=0
05950 GOTO 05970
05960 Z(3,105)=1
05970 PRINT
05980 IF F4=1 THEN 10230
05990 PRINT ≠THE NEXT THREE INPUTS SELECT THE GEOGRAPHICAL AREA≠
06000 PRINT ≠OF INTEREST. THE OPTION TO CONSIDER GENERATION OF≠
06010 PRINT ≠SECONDARY FIRES,AND THE FRACTION OF THE POPULATION≠
06020 PRINT ≠WHICH IS PROTECTED. ENTER INFO OR INPUT.≠
06030 INPUT W$
```

FIGURE B-3 (continued)

```
06040 IF W$=#INPUT# OR W$=#INFO# THEN 06080
06050 PRINT #YOUR ANSWER SHOULD HAVE BEEN EITHER INFO OR INPUT.#
06060 PRINT #PLEASE RE-TYPE YOUR ANSWER.#
06070 GOTO 06030
06080 IF W$=#INPUT# THEN 06110
06090 GOSUB 15630
06100 PRINT
06110 PRINT #BASED ON THE LOCATION OF THE SPILL AND THE WIND DIRECTION#
06120 PRINT #SELECT THE APPROPRIATE GEOGRAPHIC FILE FOR YOUR PROBLEM.#
06130 PRINT #YOU WILL NEED TO USE THE SPECIAL MAPS WHICH HAVE BEEN PRE-#
06140 PRINT #PARED SHOWING THE PORT AREAS INCLUDED IN EACH GEOGRAPHICAL #
06150 PRINT #FILE. ENTER THE FOUR DIGIT FILE NUMBER.#
06160 INPUT W
06170 G4=0
06180 IF W>1000 AND W<9999 THEN 06220
06190 PRINT #YOUR ANSWER MUST BE A FOUR(4) DIGIT CODE.#
06200 PRINT #PLEASE RETYPE YOUR ANSWER.#
06210 GOTO 06160
06220 Z(2,24)=W
06230 GOSUB 19910
06240 IF G4<>1 THEN 06260
06250 GOTO 06160
06260 Z(1,24)=10
06270 IF F4=1 THEN 09740
06280 IF Z(2,23)=1 THEN 06460
06290 PRINT
06300 PRINT #DO YOU WISH TO CONSIDER SECONDARY FIRES FROM POSSIBLE#
06310 PRINT #IGNITION OF STORAGE TANKS OF COMBUSTIBLE MATERIALS?#
06320 PRINT #ANSWER YES OR NO#
06330 INPUT W$
06340 Z(1,25)=3004
06350 IF W$=#YES# OR W$=#NO# THEN 06390
06360 PRINT #YOUR ANSWER MUST BE EITHER YES OR NO.#
06370 PRINT #PLEASE RETYPE YOUR ANSWER.#
06380 GOTO 06330
06390 IF W$=#YES# THEN 06430
06400 Z(3,25)=0
06410 M5$=W$
06420 GO TO 06450
06430 Z(3,25)=1
06440 M5$=W$
06450 IF F4=1 OR F4=2 THEN 09740
06460 PRINT
06470 PRINT #ENTER THE FRACTION OF THE POPULATION WHICH IS SHELTERED#
06480 INPUT W
06490 IF W<1.0 THEN 06530
06500 PRINT #YOUR ANSWER MUST BE A FRACTION LESS THAN 1.00.#
06510 PRINT #PLEASE RETYPE YOUR ANSWER.#
06520 GOTO 06480
06530 Z(2,26)=W
06540 Z(1,26)=5038
06550 Z(3,26)=W
06560 IF F4=1 OR F4=2 THEN 09740
06570 PRINT #  THE FINAL SET OF INPUTS IS NEEDED TO SPECIFY THE VARIOUS#
06580 PRINT #TIMES AFTER THE SPILL FOR WHICH SPILL DISPERSION AND#
06590 PRINT #EFFECTS CALCULATIONS MUST BE MADE. THE VM IS A TIME-#
06600 PRINT #STEPPED SIMULATION AND THE SPECIFICATION OF THE TIME#
06610 PRINT #STEPS IS CRITICAL TO ACHIEVING MEANINGFUL RESULTS.#
06620 PRINT
06630 PRINT
06640 PRINT #BASED ON THE INPUTS YOU HAVE ALREADY PROVIDED, THE PROGRAM#
06650 PRINT #HAS SELECTED A TIME SEQUENCE WHICH WILL PROVIDE A USEFUL#
06660 PRINT #SET OF RESULTS. THIS SEQUENCE MAKES COMPUTATIONS AT#
06670 PRINT #INFREQUENT INTERVALS WHILE THE HAZARDOUS VAPOR CLOUD#
06680 PRINT #IS TRAVERSING WATER AND AT MORE FREQUENT INTERVALS#
06690 PRINT #(EVERY TWO MINUTES) WHILE TRAVERSING LAND.#
06700 PRINT
```

FIGURE B-3 (continued)

```
06710 PRINT #TO IMPROVE ACCURACY OR COMPUTING EFFICIENCY, YOU MAY WANT#
06720 PRINT #TO CHANGE THIS TIME SEQUENCE. IF YOU DO, ENTER EITHER#
06730 PRINT #INFO OR INPUT, DEPENDING UPON WHETHER YOU NEED INSTRUCTIONS#
06740 PRINT #OR ARE ALREADY PREPARED TO INPUT. IF THE COMPUTED#
06750 PRINT #TIME SEQUENCES ARE SUFFICIENT ENTER NO.#
06760 PRINT
06770 PRINT #DO YOU WANT TO CHANGE THE TIME SEQUENCES(INFO,INPUT,OR NO)#
06780 INPUT W$
06790 B3$=W$
06800 IF W$=#NO# OR W$=#INFO# OR W$=#INPUT# THEN 06840
06810 PRINT #YOUR ANSWER MUST BE EIHER INFO, INPUT, OR NO.#
06820 PRINT #PLEASE RETYPE YOUR ANSWER.#
06830 GOTO 06780
06840 IF W$=#NO# THEN 07410
06850 IF W$=#INPUT# THEN 06880
06860 GOSUB 16120
06870 IF W$=#INFO# THEN 06780
06880 REM #READY FOR INPUT VIA RETURN#
06890 PRINT #FILL IN THE INPUTS FOR THE THREE TIME SEQUENCES#
06900 PRINT #REQUESTED BELOW. TYPE IN 0*S IF YOU DO NOT WISH TO#
06910 PRINT #USE A PARTICULAR TIME SEQUENCE.#
06920 PRINT
06930 PRINT #START OF FIRST TIME SEQUENCE IN SECONDS AFTER THE#
06940 PRINT #SPILL OCCURS.#
06950 INPUT W
06960 Z(2,27)=W
06970 Z(3,27)=W
06980 IF F4=1 THEN 09740
06990 PRINT #TIME BETWEEN DAMAGE COMPUTATIONS IN SECONDS.#
07000 INPUT W
07010 Z(2,29)=W
07020 Z(3,29)=W
07030 IF F4=1 THEN 09740
07040 PRINT #END OF FIRST TIME SEQUENCE IN SECONDS AFTER SPILL OCCURS.#
07050 INPUT W
07060 Z(3,28)=W
07070 Z(2,28)=W
07080 IF F4=1 THEN 09740
07090 PRINT #START OF SECOND TIME SEQUENCE IN MINUTES AFTER THE #
07100 PRINT #SPILL OCCURS.#
07110 INPUT W
07120 Z(2,30)=W
07130 Z(3,30)=W
07140 IF F4=1 THEN 09740
07150 PRINT #TIME BETWEEN DAMAGE COMPUTATIONS IN MINUTES.#
07160 INPUT W
07170 Z(2,32)=W
07180 Z(3,32)=W
07190 IF F4=1 THEN 09740
07200 PRINT #END OF SECOND TIME SEQUENCE IN MINUTES AFTER SPILL OCCURS.#
07210 INPUT W
07220 Z(2,31)=W
07230 Z(3,31)=W
07240 IF F4=1 THEN 09740
07250 PRINT #START OF THIRD TIME SEQUENCE IN MINUTES AFTER THE#
07260 PRINT #SPILL OCCURS.#
07270 INPUT W
07280 Z(2,33)=W
07290 Z(3,33)=W
07300 IF F4=1 THEN 09740
07310 PRINT #TIME BETWEEN DAMAGE COMPUTATIONS IN MINUTES.#
07320 INPUT W
07330 Z(2,35)=W
07340 Z(3,35)=W
07350 IF F4=1 THEN 09740
07360 PRINT #END OF THIRD TIME SEQUENCE IN MINUTES AFTER SPILL INITIATION.#
07370 INPUT W
```

FIGURE B-3 (continued)

```
07380 Z(2,34)=W
07390 Z(3,34)=W
07400 IF F4=1 THEN 09740
07410 Z(1,27)=6001
07420 Z(1,29)=6003
07430 Z(1,28)=6002
07440 Z(1,30)=6004
07450 Z(1,32)=6006
07460 Z(1,31)=6005
07470 Z(1,33)=6007
07480 Z(1,35)=6009
07490 Z(1,34)=6008
07500 IF F4=1 THEN 09740
07510 IF W$<>#NO# THEN 07900
07520 IF Z(3,105)=1 THEN 07880
07530 REM #USE DEFAULT TIME SEC#
07540 T=Z(2,22)/(60*Z(2,16))
07550 FOR I=1 TO 9
07560 I2=26+I
07570 Z(2,I2)=0
07580 Z(3,I2)=0
07590 NEXT I
07600 IF Z(3,106)=0 THEN 07640
07610 Z(3,27)=1
07620 Z(3,28)=20
07630 Z(3,29)=2
07640 IF T > 10 THEN 07690
07650 Z(3,30)=2
07660 Z(3,32)=2
07670 Z(3,31)=60
07680 GOTO 07860
07690 IF T>100 THEN 07780
07700 T1=INT((T/5))
07710 T1=T1*5
07720 Z(3,30)=5
07730 Z(3,31)=T1
07740 Z(3,32)=5
07750 Z(3,34)=T1+80
07760 Z(3,35)=2
07770 GOTO 07860
07780 T1=INT((T/50))
07790 Z(3,30)=50
07800 T1=T1*50
07810 Z(3,31)=T1
07820 Z(3,32)=50
07830 Z(3,33)=T1
07840 Z(3,34)=T1+80
07850 Z(3,35)=2
07860 IF F4=1 THEN 09740
07870 GOTO 07900
07880 Z(3,30)=Z(3,31)=80
07890 Z(3,32)=1
07900 PRINT
07910 PRINT #THE FOLLOWING IS A LIST OF THE #1VS1# FILE YOU HAVE #1#S
07920 PRINT
07930 PRINT #THE UNITS OF MEASUREMENT ARE:#
07940 PRINT TAB(10)I#PRESSURE-#,#ATMOSPHERES.#
07950 PRINT TAB(10)I#TEMPERATURE-#,01$
07960 PRINT TAB(10)I#LENGTH-#,03$
07970 PRINT TAB(10)I#VOLUME-#,02$
07980 PRINT TAB(10)I#VELOCITY-#,04$
07990 PRINT
```

FIGURE B-3 (continued)

```
08000 REM ≠LIST OUT THE UIM FILE TO THE TERMINAL≠
08010 PRINT USING 08020
08020 :   NUMBER OF INPUT     NAME OF INPUT                        USER INPUT
08030 PRINT
08040 PRINT USING 08050,M1$
08050 :          1           CHEMICAL CODE                      >##########
08060 PRINT USING 08070,Z(2,2)
08070 :          2           CARGO TEMPERATURE                     ####.##
08080 PRINT USING 08090,Z(2,3)
08090 :          3           TANK PRESSURE                          ###.#
08100 PRINT USING 08110,Z(2,4)
08110 :          4           TANK CAPACITY                      #######.##
08120 PRINT USING 08130,Z(2,5)
08130 :          5           TANK HEIGHT                            ###.##
08140 PRINT USING 08150,Z(2,6)
08150 :          6           FRACTION TANK FILLED                     #.##
08160 PRINT USING 08170,Z(2,7)
08170 :          7           HOLE DIAMETER                          ###.##
08180 PRINT USING 08190,Z(2,8)
08190 :          8           HEIGHT OF CENTERLINE                  ####.##
08200 PRINT USING 08210,Z(2,9)
08210 :          9           HEIGHT OF HOLE BOTTOM                  ###.##
08220 PRINT USING 08230,Z(2,10)
08230 :         10           SPILL LOCATION                              #
08240 PRINT USING 08250,Z(2,11)
08250 :         11           WATER TEMPERATURE                      ###.##
08260 IF Z(2,10)=1 THEN 08350
08270 PRINT USING 08280,Z(2,12)
08280 :         12           CHANNEL WIDTH                         ####.##
08290 PRINT USING 08300,Z(2,13)
08300 :         13           AVERAGE RIVER DEPTH                    ###.##
08310 PRINT USING 08320,Z(2,14)
08320 :         14           AVERAGE RIVER VELOCITY                  ##.##
08330 PRINT USING 08340,Z(2,15)
08340 :         15           TYPE OF RIVER BANKS                         #
08350 PRINT USING 08360,Z(2,16)
08360 :         16           AVERAGE WIND SPEED                     ###.##
08370 PRINT USING 08380,Z(2,17)
08380 :         17           WIND DIRECTION                          ###.#
08390 PRINT USING 08400,Z(2,18)
08400 :         18           AIR TEMPERATURE                       ####.##
08410 PRINT USING 08420,M5$
08420 :         19           ATMOSPHERIC STABILITY CODE         >##########
08430 IF V$=≠NEW≠ THEN 08470
08440 LET L1$=SUBSTR(L$(1),1,2)
08450 LET L2$=SUBSTR(L$(1),3,2)
08460 LET L3$=SUBSTR(L$(1),5,2)
08470 PRINT USING 08480,L1$,L2$,L3$
08480 :         20           DEGREES LATITUDE                  >## >## >##
08490 IF V$=≠NEW≠ THEN 08530
08500 LET L4$=SUBSTR(L$(2),1,3)
08510 LET L5$=SUBSTR(L$(2),4,2)
08520 LET L6$=SUBSTR(L$(2),6,2)
08530 PRINT USING 08540,L4$,L5$,L6$
08540 :         21           DEGREES LONGITUDE                >### >## >##
08550 PRINT USING 08560,Z(2,22)
08560 :         22           DISTANCE OF SPILL TO SHORE           #####.##
08570 PRINT USING 08580,Z(2,23)
08580 :         23           TYPE OF DAMAGE                              #
08590 PRINT USING 08600,Z(2,24)
08600 :         24           GEOGRAPHICAL FILE                        ####
08610 IF Z(2,23)=1 THEN 08640
08620 PRINT USING 08630,M5$
08630 :         25           SECONDARY FIRES                          >###
08640 PRINT USING 08650,Z(2,26)
08650 :         26           POPULATION SHELTERED                     #.##
08660 B3=0
08670 Z(1,121)=30
```

FIGURE B-3 (continued)

```
08680 IF B3$=#NO# THEN 08890
08690 B3=1
08700 PRINT USING 08710,Z(2,27)
08710 :          27          BEGIN FIRST TIME SEQUENCE             ====
08720 PRINT USING 08730,Z(2,29)
08730 :          28          BETWEEN FIRST TIME SEQUENCE            ===
08740 PRINT USING 08750,Z(2,28)
08750 :          29          END FIRST TIME SEQUENCE               ====
08760 PRINT USING 08770,Z(2,30)
08770 :          30          BEGIN SECOND TIME SEQUENCE            ====
08780 PRINT USING 08790,Z(2,32)
08790 :          31          BETWEEN SECOND TIME SEQUENCE           ===
08800 PRINT USING 08810,Z(2,31)
08810 :          32          END SECOND TIME SEQUENCE              ====
08820 PRINT USING 08830,Z(2,33)
08830 :          33          BEGIN THIRD TIME SEQUENCE             ====
08840 PRINT USING 08850,Z(2,35)
08850 :          34          BETWEEN THIRD TIME SEQUENCE            ===
08860 PRINT USING 08870,Z(2,34)
08870 :          35          END THIRD TIME SEQUENCE               ====
08880 GOTO 08900
08890 B3=0
08900 PRINT
08910 PRINT
08920 PRINT
08930 PRINT #DO YOU WANT TO MAKE ANY CHANGES TO#
08940 PRINT # THE CONTENTS OF THIS FILE (YES OR NO)#;
08950 INPUT X2$
08960 IF X2$=#NO# THEN 09020
08970 IF X2$=#YES# THEN 09000
08980 PRINT #YOUR ANSWER MUST BE EITHER YES OR NO.#
08990 GOTO 08930
09000 IF K$=#YES# THEN 09360
09010 GOTO 09160
09020 PRINT
09030 PRINT #DO YOU WANT TO RUN A VM SIMULATION#
09040 PRINT #USING THESE DATA (YES OR NO)#;
09050 INPUT Y$
09060 IF Y$=#YES# OR Y$=#NO# THEN 09190
09070 PRINT #PLEASE ENTER EITHER YES OR NO.#
09080 GOTO 09030
09090 IF W$=#LIST# THEN 07940
09100 IF W$=#YES# AND K$<>#YES# THEN 09160
09110 IF W$=#NO# THEN 09020
09120 IF W$=#YES# THEN 09360
09130 PRINT #YOUR ANSWER MUST BE EITHER YES OR NO.#
09140 PRINT #PLEASE RETYPE YOUR ANSWER.#
09150 GOTO 09800
09160 F4=1
09170 PRINT #INPUT NUMBER#;
09180 GOTO 09390
09190 PRINT
09200 PRINT #DO YOU WANT TO SAVE THIS FILE ON DISK (YES OR NO)#;
09210 INPUT W$
09220 IF W$=#NO# THEN 09270
09230 IF W$=#YES# THEN 09260
09240 PRINT #A SIMPLE YES OR NO WILL DO.#
09250 GOTO 09200
09260 GOTO 09290
09270 IF Y$=#NO# THEN 19850
09280 IF Y$=#YES# THEN 18800
09290 IF F8=0 AND F4>0 THEN 09320
09300 IF F8=0 THEN 17720
09310 IF F4=1 THEN 09340
09320 E$=C$
09330 GOSUB 17740
09340 GOSUB 16490
09350 GOTO 09270
```

FIGURE B-3 (continued)

```
09360 PRINT #PLEASE ENTER THE NUMBER OF THE INPUT THAT YOU WANT#
09370 PRINT #TO CHANGE.#
09380 F4=1
09390 INPUT C
09400 C=INT(C)
09410 IF K$<>#YES# AND C>0 AND C<36 THEN 09590
09420 IF C>0 AND C<36 THEN 09440
09430 GOTO 09530
09440 PRINT #DO YOU WANT THE INFORMATION STATEMENT THAT CONTAINS#
09450 PRINT #INFORMATION ABOUT THE INPUT THAT YOU WISH TO CHANGE.#
09460 INPUT W1$
09470 IF W1$=#YES# OR W1$=#NO# THEN 09510
09480 PRINT #YOU ANSWER CAN ONLY BE YES OR NO.#
09490 PRINT #PLEASE RETYPE YOUR ANSWER.#
09500 GO TO 09460
09510 IF C=1 THEN 09700
09520 GOTO 09570
09530 PRINT #THE RANGE OF YOUR INPUT MUST BE BETWEEN 1 AND 35 INCLUSIVE.#
09540 PRINT #YOUR ATTEMPT TO EXCEED IT IS INVALID.#
09550 PRINT #PLEASE RETYPE YOUR ANSWER.#
09560 GOTO 09360
09570 IF W1$=#NO# THEN 09590
09580 GOSUB 10700
09590 IF C=1 THEN 09700
09600 IF C>10 THEN 09620
09610 ON C GOTO 09700, 01310, 01490, 01670, 01770, 01870, 02100, 02280, 02390, 09820
09620 IF C>20 THEN 09650
09630 C=C-10
09640 ON C GOTO 02880, 09940, 09940, 09940, 09940, 03710, 03810, 03920, 10970, 04400
09650 IF C>30 THEN 10670
09660 C=C-20
09670 IF C>6 AND B3$<>#YES# THEN 10500
09680 ON C GOTO 04820 , 05220 , 10190 , 10990 , 10430 , 06470 , 06920 , 06990 , 07040 , 070
09690 PRINT USING 08750,Z(2,28)
09700 PRINT #TO CHANGE THE CHEMICAL CODE YOU MUST DO SO BY CREATING#
09710 PRINT #A NEW FILE. EDITING THE CHEMICAL CODE IS NOT POSSIBLE#
09720 PRINT #BECAUSE OF THE DEPENDENCY OF THE OTHER VARIABLES#
09730 PRINT #ON THE CHEMICAL PROPERTIES,ETC.#
09740 IF F6<>2 THEN 09770
09750 PRINT #MORE CHANGES(YES,NO OR LIST)#!
09760 GOTO 09800
09770 PRINT #DO YOU WANT TO CHANGE ANY OF YOUR OTHER INPUTS+#
09780 PRINT #INPUT YES OR NO.#
09790 PRINT #IF YOU NEED A LIST OF YOUR FILE ANSWER LIST.#
09800 INPUT W$
09810 GOTO 09090
09820 IF F6=2 THEN 02730
09830 PRINT #YOUR REQUEST TO CHANGE THE SPILL LOCATION WILL BE#
09840 PRINT #PROCESSED. HOWEVER PLEASE NOTE THAT 1) IF YOU ARE#
09850 PRINT #CHANGING FROM AN OPEN WATER LOCATION(CODE=1) TO A#
09860 PRINT #RIVER OR CHANNEL LOCATION FURTHER QUESTIONS ABOUT#
09870 PRINT #THE RIVER OR CHANNEL WILL BE ASKED OR 2) IF YOU ARE#
09880 PRINT #CHANGING FROM A RIVER OR CHANNEL LOCATION TO AN OPEN#
09890 PRINT #WATER LOCATION, YOUR PREVIOUS INPUTS WITH REGARD TO#
09900 PRINT #THE CHANNEL OR RIVER WILL BE IGNORED.#
09910 GOTO 02710
09920 IF Z(2,10)=1 THEN 09740
09930 GOTO 03040
09940 IF Z(2,10)=2 THEN 09990
09950 PRINT #THIS INPUT IS USED ONLY WHEN THE SPILL LOCATION IS IN A #
09960 PRINT #RIVER. YOUR PREVIOUS ANSWER SPECIFIED AN OPEN WATER SPILL#
09970 PRINT #LOCATION. THE EDITING PROCESS CANNOT ENABLE.#
09980 GOTO 09740
09990 C=C-1
10000 F4=3
10010 ON C GOTO 03040, 03160, 03260, 03370
```

FIGURE B-3 (continued)

```
10020 IF B3$=#NO# THEN 07530
10030 PRINT # THE WIND SPEED AND DISTANCE FROM THE SPILL TO SHORE DATA#
10040 PRINT #ARE USED BY THE PROGRAM TO CALCULATE THE DEFAULT TIME SEQUENCES.#
10050 PRINT #SINCE YOU OVERRODE THE TIME SEQUENCES, THIS INPUT HAS#
10060 PRINT #NO REAL MEANING. DO YOU WANT THESE SEQUENCES ERASED?#
10070 PRINT #IF YES, THE PROGRAM WILL COMPUTE THE TIME SEQUENCES#
10080 PRINT #USING THE NEW DATA.#
10090 PRINT #INPUT YES OR NO.#
10100 INPUT W$
10110 IF W$=#YES# OR W$=#NO# THEN 10150
10120 PRINT #YOUR ANSWER MUST BE EITHER YES OR NO.#
10130 PRINT #PLEASE RETYPE YOUR ANSWER.#
10140 GOTO 10100
10150 IF W$=#NO# THEN 09740
10160 B3$=#YES#
10170 F4=1
10180 GOTO 07530
10190 T1=Z(2,23)
10200 IF F6<>2 THEN 05420
10210 PRINT #DAMAGE CODE(1,2,3 OR 4)#;
10220 GOTO 05620
10230 IF Z(2,23)=T1 THEN 09740
10240 IF T1>1 AND Z(2,23)>1 THEN 10370
10250 IF T1=1 AND Z(2,23)>1 THEN 10310
10260 PRINT
10270 PRINT #YOUR REQUESTED CHANGE TO TOXIC DAMAGE HAS BEEN PROCESSED.#
10280 PRINT #YOUR PREVIOUS INPUTS WITH REGARD TO FIRE DAMAGE WILL BE#
10290 PRINT #DISCARDED.#
10300 GOTO 09740
10310 F4=2
10320 PRINT
10330 PRINT #YOUR REQUESTED CHANGE TO FIRE DAMAGE HAS BEEN PROCESSED.#
10340 PRINT #THE PROGRAM WILL NOW ASK YOU FURTHER QUESTIONS NEEDED FOR#
10350 PRINT #THE VULNERABILITY MODEL IN MODELING FIRE DAMAGE.#
10360 GOTO 06300
10370 PRINT
10380 PRINT #YOUR REQUESTED CHANGE IN THE TYPE OF FIRE DAMAGE HAS BEEN#
10390 PRINT #PROCESSED. YOUR INPUTS WITH REGARD TO SECONDARY FIRES AND#
10400 PRINT #THE FRACTION OF THE POPULATION SHELTERED HAVE NOT CHANGED.#
10410 PRINT #YOU MAY EDIT THESE SEPARATELY IF YOU WISH TO CHANGE THEM.#
10420 GOTO 09740
10430 IF Z(2,23)>1 THEN 06300
10440 GOTO 10450
10450 PRINT #THIS USER INPUT IS ONLY USED WHEN REQUESTING THE VULNERABILITY#
10460 PRINT #MODEL TO SIMULATE FIRE DAMAGE. SINCE YOU REQUESTED A RUN#
10470 PRINT #MODELING TOXIC DAMAGE, THIS INPUT IS NOT USED. THE EDITING#
10480 PRINT #PROCESS CANNOT BE ENABLED.#
10490 GOTO 09740
10500 PRINT
10510 PRINT #THE PROGRAM HAS CALCULATED THE DEFAULT TIME SEQUENCES, PER#
10520 PRINT #YOUR REQUEST. DO YOU NOW WISH TO OVERRIDE THESE TIME SEQUENCES?#
10530 PRINT #INPUT EITHER YES OR NO.#
10540 INPUT W$
10550 IF W$=#YES# OR W$=#NO# THEN 10590
10560 PRINT #YOUR INPUT MUST BE EITHER YES OR NO.#
10570 PRINT #PLEASE RETYPE YOUR ANSWER.#
10580 GOTO 10540
10590 IF W$=#YES# THEN 10610
10600 GOTO 09740
10610 B3$=#YES#
10620 PRINT #BECAUSE OF THE INTERDEPENDENCY OF THE TIME SEQUENCES, YOU#
10630 PRINT #WILL BE REQUESTED TO CHANGE ALL OF THEM DURING ONE EDIT.#
10640 PRINT
10650 F4=2
10660 GOTO 04920
```

FIGURE B-3 (continued)

```
10670 IF B3$<>#YES# THEN 10500
10680 C=C-30
10690 ON C GOTO 07150 , 07200 , 07250 , 07310 , 07360
10700 REM #SUB USED TO CONTROL BRANCHING FOR INFORMATION ROUTINES#
10710 IF C>3 THEN 10740
10720 GOSUB 13960
10730 GOTO 10960
10740 IF C>6 THEN 10770
10750 GOSUB 11320
10760 GOTO 10960
10770 IF C>9 THEN 10800
10780 GOSUB 12440
10790 GOTO 10960
10800 IF C>15 THEN 10830
10810 GOSUB 14580
10820 GOTO 10960
10830 IF C>19 THEN 10860
10840 GOSUB 13180
10850 GOTO 10960
10860 IF C>22 THEN 10890
10870 GOSUB 14910
10880 GOTO 10960
10890 IF C>23 THEN 10920
10900 GOSUB 15200
10910 GOTO 10960
10920 IF C>26 THEN 10950
10930 GOSUB 15630
10940 GOTO 10960
10950 GOSUB 16120
10960 RETURN
10970 IF F6=2 THEN 04100
10980 GOTO 04070
10990 IF F6<>2 THEN 06100
11000 PRINT #GEOGRAPHIC FILE#I
11010 GOTO 06160
11020 REM #SUB TO SET UP CHEMICAL FILE#
11030 DATA 0,.841,36000,350,.1100,1,1,1,1,4,1.00,-9.9315,2.0488,0,0,.26,100,-26.
11040 DATA 0,.682,36000,0,1500,1, ,0,1,2,1.36,-28.33,2.27,0,0,100,,100,999
11050 DATA 0,1.59,0,0,0,1,0,0,1,0,2.50,-6.29,.408,0,0,1000,100,999
11060 DATA 0,1.424,0,0,0,1,0,0,1,0,2.64,-36.45,3.13,-2.4,2.9,3.4,100,999
11070 DATA 0,1.191,0,0,0,1,1,0,1,0,1.0,-16.85,2.804,0,0,10.,100,999
11080 DATA 0,.992,0,0,0,1,1,0,1,0,1.00,-25.87,3.354,2.79E,2.9152,100,999
11090 DATA 0,.4150,13720,338,.1069,1,0,1,0,2,2.75,0,0,0,0,0,100,-161
11100 DATA 0,1.68,0,0,0,1,0,0,1,0,1.0,-56.81,5.27,0,0,1000,100,999
11110 DATA 0,1.38,0,0,0,1,0,0,1,0,1.00,-19.274,3.686,0,0,5.,100,999
11120 DATA 0,.499,0,0,0,1,1,0,1,0,1.43,-29.422,3.008,0,0,20,100,999
11130 DATA 0,1.374,36000,350,.1100,1,1,0,1,0,1.43,-31.343,3.008,0,0,70,100,999
11140 DATA 0,1.434,0,0,0,1,1,0,1,0,1.00,-15.67,2.1,0,0,10,100,999
11150 DATA 0,.58,15845,350,.1079,0,0,1,0,6.5,2.75,0,0,0,0,0,100,-60
11160 DATA 0,.60,15968,432,.1118,0,0,1,0,6,2.75,0,0,0,0,0,100,-79
11170 DATA 0,.70,15845,350,.1079,0,0,1,0,6,2.75,0,0,0,0,0,100,-45
11180 DATA 0,.55,15827,350,.1100,0,0,1,0,5.5,2.75,0,0,0,0,0,100,69
11190 DATA 0,.702,15903,350,.1078,0,0,1,0,12.5,2.75,0,0,0,0,0,100,-40
11200 DATA 0,.63,15867,385,.1077,0,0,1,0,8,2.75,0,0,0,0,0,100,-49
11210 DATA 0,.53,15809,390,.1130,0,0,1,0,5,2.75,0,0,0,0,0,100,-53
11220 DATA 0,.52,15968,350,.1112,0,0,1,0,4.5,2.75,0,0,0,0,0,100,-108
11230 DATA 0,.91,14613,350,.1100,0,0,1,0,2.5,2.75,0,0,0,0,0,100,-78
11240 DATA 0,.81,0,0,0,1,1,0,1,4.5,1.43,-29.42,3.008,0,,0,,1000,100,999
11250 DATA 0,.86,800,,350,.1174,1,1,1,1,4,2.0,-7.415,.509,0,0,1000,100,-37.
11260 DATA 0,.87,800,,350,.1130,1,0,1,1,9,2.5,-6.794,.408,0,0,1000,100,7.2
11270 DATA 0,.78,800,350,.1100,,1,1,1,0,2.5,2.75,0,0,0,0,1000,100,-38.
11280 DATA 0,.68,800,350,1100,,1,1,1,0,4,25,2.75,0,0,0,0,1000,100,-48.
11290 DATA 0,.92,800,350,.1100,,1,0,1,0,1.5,2.75,0,0,0,0,1000,100,0.
11300 MAT READ C3(27,18)
11310 RETURN
```

FIGURE B-3 (continued)

```
11320 REM INFO SUB: G 4,5,6
11330 PRINT
11340 PRINT
11350 PRINT #INFORMATION ON TANK CAPACITIES AND SIZES FOR VARIOUS#
11360 PRINT #CLASSES OF TANK SHIPS IS GIVEN IN THE TABLE BELOW.#
11370 PRINT #IN GENERAL EACH TANKSHIP CONTAINS SEVERAL TANKS AS#
11380 PRINT #SHOWN. NORMALLY TANKS ARE FILLED WITH LIQUID CARGO#
11390 PRINT #TO 98% CAPACITY(I.E. FRACTION FILLED = .98). ONLY#
11400 PRINT #DURING LOADING OR UNLOADING WOULD THE TANKS BE PARTIALLY#
11410 PRINT #FILLED. GASEOUS CARGOES CAN BE CONSIDERED TO BE 100%#
11420 PRINT #FILLED(I.E. FRACTION FILLED = 1.00).#
11430 PRINT
11440 PRINT #THE FOLLOWING IS A TABLE OF REPRESENTATIVE VALUES#
11450 PRINT #FOR TANK CAPACITIES AND SIZES.#
11460 PRINT
11470 PRINT USING 11480
11480 :SHIP SIZE          AVERAGE CAPACITY OF EACH TANK          TANK HEIGHT
11490 PRINT USING 11500
11500 :               AVG.
11510 PRINT USING 11520
11520 :THOUSANDS  NO. OF        BRITISH                MKS     BRITISH     MKS
11530 PRINT USING 11540
11540 :     OF      TANKS       THOUSANDS
11550 PRINT USING 11560
11560 :DEADWEIGHT  PER             OF                 CUBIC
11570 PRINT USING 11580
11580 :    TONS     SHIP         GALLONS              METERS     FEET      METERS
11590 PRINT
11600 PRINT USING 11610
11610 :   1-10        16          110                   420        32        9.75
11620 PRINT USING 11630
11630 :  10-20        20          214                   770        41       12.50
11640 PRINT USING 11650
11650 :  20-30        25          312                  1200        45       13.70
11660 PRINT USING 11670
11670 :  30-50        10          956                  3600        50       15.25
11680 PRINT USING 11690
11690 :  50-70         6         1970                  7500        56       17.10
11700 PRINT USING 11710
11710 :  70-125        8         2570                  9700        63       19.20
11720 PRINT USING 11730
11730 : 125-175        8         4540                 17200        70       21.35
11740 PRINT USING 11750
11750 : 175-225        6         8160                 30900        73       22.25
11760 PRINT USING 11770
11770 : 225-300        6        10200                 38500        84       25.60
11780 PRINT USING 11790
11790 :  > 300         8        13500      48600                   95       29.00
11800 PRINT
11810 PRINT #LNG#
11820 PRINT USING 11830
11830 :  50-70         5        10300                 25000        98       30.00
11840 PRINT
11850 PRINT
11860 PRINT #TYPE IN READY WHEN YOU ARE READY TO ANSWER THE QUESTIONS.#
11870 INPUT W$
11880 PRINT
11890 PRINT
11900 PRINT
11910 PRINT
11920 RETURN
11930 REM #SUB TO EDIT THREE-CODE#
11940 F2=0
11950 A$=#AALSYACETCLL#CCPFALNGMTPPPGMCAPUSSFU#
11960 FOR I=1 TO LEN(A$)-1 STEP 3
11970 IF SUBST(A$,I,3)=W$ THEN 07600
11980 NEXT I
```

FIGURE B-3 (continued)

```
11990 I1=36
12000 A3$=#BUTBTNEETLPGOANPTAPRPPPLVCHACNPOXTOLAADDHAMTC#
12010 FOR K=1 TO LEN(A3$) STEP 3
12020 IF SUBSTR(A3$,K,3)=W$ THEN 12050
12030 NEXT K
12040 GOTO 12090
12050 I=I1+K
12060 F2=1
12070 K4=(I+2)/3
12080 GOSUB 12100
12090 RETURN
12100 REM #SUB TO SET-UP CHEMICAL PROPERTIES#
12110 Z(1,135)=2006
12120 Z(3,135)=C3(K4,1)
12130 Z(3,136)=C3(K4,2)
12140 Z(1,137)=2011
12150 Z(3,137)=C3(K4,3)
12160 Z(1,138)=2022
12170 Z(3,138)=1.0
12180 Z(1,139)=2033
12190 Z(3,139)=C3(K4,4)
12200 Z(1,140)=1019
12210 Z(3,140)=C3(K4,5)
12220 Z(1,141)=2043
12230 Z(3,141)=C3(K4,6)
12240 Z(1,142)=2046
12250 Z(3,142)=0.0
12260 Z(1,143)=5002
12270 Z(3,143)=C3(K4,7)
12280 Z(3,144)=C3(K4,8)
12290 Z(3,145)=C3(K4,9)
12300 Z(1,146)=5005
12310 Z(3,146)=0
12320 Z(1,147)=5019
12330 Z(3,147)=C3(K4,10)
12340 FOR I=1 TO 7
12350 I1=147+I
12360 I2=5029+I
12370 I3=10+I
12380 Z(1,I1)=I2
12390 Z(3,I1)=C3(K4,I3)
12400 NEXT I
12410 Z(1,155)=5020
12420 Z(3,155)=C3(K4,18)
12430 RETURN
12440 REM #SUB FOR INFO Q 7,8,9#
12450 PRINT
12460 PRINT #FOR IRREGULAR RUPTURES, CONSIDER THE HOLE TO BE A CIRCLE#
12470 PRINT #WITH AREA EQUAL TO THE RUPTURE AREA AND COMPUTE THE DIAMETER#
12480 PRINT #AS EQUAL TO THE SQUARE ROOT OF (1.27 X AREA).#
12490 PRINT
12500 PRINT #IF YOU DESIRE TO SIMULATE A RAPID SPILL OF ALL OF THE TANK'S#
12510 PRINT #CONTENTS, USE THE FOLLOWING PARAMETERS:#
12520 PRINT
12530 IF F1=1 THEN 12560
12540 C7$=#>= 1 METER.#
12550 GOTO 12570
12560 C7$=#>= 3.3 FEET.#
12570 PRINT USING 12580, C7$
```

FIGURE B-3 (continued)

```
12580 :       HOLE DIAMETER (D) <################
12590 PRINT USING 12600
12600 :       HEIGHT OF HOLE+S CENTERLINE ABOVE WATERLINE (C) = D/2
12610 PRINT USING 12620
12620 :       HEIGHT OF BOTTOM OF HOLE ABOVE BOTTOM OF TANK (B) = 0
12630 PRINT
12640 PRINT #THIS PLACES THE BOTTOM OF THE TANK AT THE WATERLINE, WHICH#
12650 PRINT #IS NOT NECESSARILY A REALISTIC SITUATION, BUT IT WILL SIM-#
12660 PRINT #ULATE A RAPID SPILLAGE OF THE ENTIRE CARGO IN THE TANK.#
12670 PRINT
12680 PRINT #FOR REALISTIC SPILLS IT WOULD BE HELPFUL TO MAKE A SKETCH#
12690 PRINT #SHOWING THE SHIP, THE TANK, THE HOLE POSITION AND THE WATER-#
12700 PRINT #LINE. ALSO, THE FOLLOWING RELATIONSHIP IS USEFUL IN DETER-#
12710 PRINT #MINING AN APPROXIMATE VALUE FOR B:#
12720 PRINT
12730 PRINT #      B = C + S - D/2#
12740 PRINT #WHERE S IS THE DRAFT OF THE SHIP.#
12750 PRINT
12760 PRINT #IN THIS RELATIONSHIP, C WILL HAVE A NEGATIVE VALUE IF THE#
12770 PRINT #CENTERLINE OF THE HOLE IS BELOW THE WATERLINE. AS AN EXAMPLE#
12780 PRINT #CONSIDER THE HOLE DIAMETER (D) TO BE 2 METERS AND THE SHIP+S#
12790 PRINT #DRAFT TO BE 10 METERS. IF THE HOLE+S CENTERLINE IS AT THE#
12800 PRINT #WATERLINE (C=0), THEN B = 10 - 2/2 = 9 METERS. THE DRAFTS#
12810 PRINT #FOR VARIOUS SIZES OF SHIPS ARE GIVEN IN THE FOLLOWING#
12820 PRINT #TABLE:#
12830 PRINT
12840 PRINT
12850 PRINT
12860 PRINT #          TANK SHIP SIZE                    SHIP DRAFT#
12870 PRINT #           (THOUSANDS OF#
12880 IF F1=2 THEN 13030
12890 PRINT #         DEAD WEIGHT TONS)                  (FEET)#
12900 PRINT #         -----------------                -----------#
12910 PRINT
12920 PRINT #               1-10                          22#
12930 PRINT #               10-20                         28#
12940 PRINT #               20-30                         33#
12950 PRINT #               30-50                         35#
12960 PRINT #               50-70                         41#
12970 PRINT #               70-125                        46.5#
12980 PRINT #              125-175                        55.5#
12990 PRINT #              175-225                        60#
13000 PRINT #              225-300                        68.7#
13010 PRINT #               > 300                         77.5#
13020 GOTO 13150
13030 PRINT #         DEAD WEIGHT TONS)                 (METERS)#
13040 PRINT #         -----------------                -----------#
13050 PRINT
13060 PRINT #               1-10                          6.7#
13070 PRINT #               20-30                         10#
13080 PRINT #               30-50                         10.7#
13090 PRINT #               50-70                         12.5#
13100 PRINT #               70-125                        14.2#
13110 PRINT #              125-175                        17#
13120 PRINT #              175-225                        18.3#
13130 PRINT #              225-300                        21#
13140 PRINT #               > 300                         23.6#
13150 PRINT #TYPE IN READY WHEN YOU ARE READY TO INPUT YOUR ANSWERS.#
13160 INPUT W$
13170 RETURN
```

FIGURE B-3 (continued)

```
13180 REM #IPU SUB U 16,17,18,A19#
13190 PRINT
13200 PRINT #TO ASSIST IN THE SPECIFICATION OF REALISTIC WEATHER CONDITIONS#
13210 PRINT #FOR YOUR SPILL SIMULATION, REPRESENTATIVE VALUES FOR THE#
13220 PRINT #U.S. PORTS OF INTEREST ARE PRESENTED IN THE TABLE BELOW.#
13230 PRINT #ONLY THE PREVAILING WIND DIRECTION IS SHOWN. HOWEVER, IN#
13240 PRINT #GENERAL ALL WIND DIRECTIONS ARE POSSIBLE. THE WIND DIRECTION#
13250 PRINT #IN DEGREES IS MEASURED AS THE ANGLE BETWEEN NORTH AND THE #
13260 PRINT #DIRECTION THE WIND IS BLOWING TOWARDS; I.E. A SOUTHWEST#
13270 PRINT #WIND IS CONSIDERED TO BE 45 DEGREES(MEASURED CLOCKWISE#
13280 PRINT #FROM NORTH). THE TEMPERATURES ARE GIVEN IN TERMS OF THE #
13290 PRINT #AVERAGE OF THE MINIMUMS (OCCURRING AT NIGHT) AND THE#
13300 PRINT #AVERAGE OF THE MAXIMUMS(OCCURRING DURING THE DAY).#
13310 PRINT
13320 IF F1=1 THEN 13490
13330 PRINT
13340 PRINT USING 13350
13350 :                      SUMMER                                WINTER
13360 PRINT USING 13370
13370 :         MEAN WIND  PREVAILING  AVERAGE    MEAN WIND  PREVAILING  AVERAGE
13380 PRINT USING 13390
13390 :           SPEED       WIND      TEMP(C)     SPEED       WIND     TEMP(C)
13400 PRINT USING 13410
13410 :          (M/SEC)   DIRECTION   MIN  MAX    (M/SEC)   DIRECTION  MIN MAX
13420 PRINT USING 13430
13430 : L.A.      3.44       67.5     16.7 23.7     2.95         90     7.4 17.5
13440 PRINT USING 13450
13450 : NEW ORL.  2.86       45       22.9 32.4     4.24        180     6.4 16.8
13460 PRINT USING 13470
13470 : N.Y.C.    4.78        0       19.3 28.4     6.0         135    -4.   3.3
13480 GOTO 13630
13490 PRINT USING 13500
13500 :                      SUMMER                                WINTER
13510 PRINT USING 13520
13520 :         MEAN WIND  PREVAILING  AVERAGE    MEAN WIND  PREVAILING  AVERAGE
13530 PRINT USING 13540
13540 :           SPEED       WIND      TEMP(F)     SPEED       WIND     TEMP(F)
13550 PRINT USING 13560
13560 :         (FT/SEC)   DIRECTION   MIN  MAX   (FT/SEC)   DIRECTION  MIN  MAX
13570 PRINT USING 13580
13580 : L.A.      11.29      67.5     62.1 74.8     9.68         90    45.4 63.5
13590 PRINT USING 13600
13600 : NEW ORL.  9.38       45       73.3 90.4    13.93        180    43.5 62.3
13610 PRINT USING 13620
13620 : N.Y.C.    15.69       0       66.9 83.2    19.89        135    24.8 30.0
13630 PRINT
13640 PRINT
13650 PRINT #YOU ARE NOT BOUND TO THESE TABLES, HOWEVER, THE UIM WILL NOT#
13660 PRINT #ACCEPT AIR TEMPERATURES OUTSIDE OF THE RANGE -40 TO +49 DEGREES#
13670 PRINT #CELSIUS (-40 TO 120 FAHRENHEIT).#
13680 PRINT
13690 PRINT #CONTINUE, (TYPE IN YES WHEN READY)#
13700 INPUT Q$
13710 PRINT
13720 PRINT
13730 PRINT
13740 PRINT
13750 PRINT #FOR ATMOSPHERIC STABILITY, YOU MUST SPECIFY THE PASQUILL-#
13760 PRINT #GIFFORD ATMOSPHERIC STABILITY CLASS. ONLY THREE CLASSES#
13770 PRINT #ARE ACCEPTED IN THE VM: B, D, AND F. THESE ARE DEFINED#
13780 PRINT #BELOW.#
13790 PRINT
```

FIGURE B-3 (continued)

```
13800 PRINT #  B REPRESENTS UNSTABLE CONDITIONS WHICH OCCUR ONLY ON SUNNY#
13810 PRINT #  DAYS WITH WINDS LESS THEN 4 METERS PER SECOND(13 FT PER#
13820 PRINT #  SECOND.)#
13830 PRINT
13840 PRINT #  D REPRESENTS NEUTRAL CONDITIONS WHICH OCCUR DAY OR NIGHT#
13850 PRINT #  DURING HEAVY OVERCAST PERIODS, OR DURING LIGHT OVERCAST#
13860 PRINT #  PERIODS WHEN WIND SPEEDS ARE 4 METERS PER SECOND(13 FT#
13870 PRINT #  PER SECOND) OR GREATER.#
13870 PRINT #  PER SECOND) OR GREATER.#
13880 PRINT
13890 PRINT #  F REPRESENTS HIGHLY STABLE CONDITIONS WHICH OCCUR ONLY#
13900 PRINT #  AT NIGHT DURING LIGHT OR NO OVERCAST PERIODS WITH WINDS#
13910 PRINT #  LESS THAN 4 METERS PER SECOND(13 FT PER SECOND).#
13920 PRINT
13930 PRINT #TYPE IN READY WHEN YOU ARE READY TO ANSWER THE QUESTIONS:#
13940 INPUT W$
13950 RETURN
13960 REM #INFO SUB FOR QUESTIONS 1-3#
13970 PRINT #   THE FOLLOWING TABLE LISTS THE CHEMICALS THAT CAN BE#
13980 PRINT #SIMULATED BY THE VM THROUGH OPERATION OF THE UIM.  THE#
13990 PRINT #THREE-LETTER CHEMICAL CODE AND THE PRINCIPAL TYPE OF HAZARD#
14000 PRINT #IS GIVEN FOR EACH CHEMICAL.  ALSO SHOWN ARE THE BOILING#
14010 PRINT #POINTS IN DEGREES FAHRENHEIT UNDER STANDARD ATMOSPHERIC#
14020 PRINT #PRESSURE (1 ATMOSPHERE) AND THE VAPOR PRESSURES IN ATMOS-#
14030 PRINT #PHERES AT 68 DEGREES FAHRENHEIT.#
14040 PRINT
14050 PRINT #                                    BOILING POINT  VAPOR PRESS.#
14060 PRINT #    CHEMICAL            CODE   H*    AT 1 ATM.    AT 68 DEG. F#
14070 PRINT #    --------            ----   -    -----------  --------------#
14080 PRINT #    ACETALDEHYDE        AAD    F         70             1.#
14090 PRINT #    ACROLEIN            ARL    T,F      126             .3#
14100 PRINT #    ACRYLONITRILE       ACN    T        171             .1#
14110 PRINT #    AMMONIA(ANHYD)      AHA    T        -28            9.5#
14120 PRINT #    BUTANE              BUT    F         31             2.#
14130 PRINT #    BUTYLENE            BTN    F         21            1.4#
14140 PRINT #    CARBON TETRA.       CHT    T        168             .1#
14150 PRINT #    CHLORINE            CLX    T        -29             6.#
14160 PRINT #    DIMETHYLAMINE       DMA    F         45            2.5#
14170 PRINT #    ETHYL ETHER         EET    F         94            .58#
14180 PRINT #    HYDROGEN CHLORIDE   HDC    T       -110            41.#
14190 PRINT #    HYDROGEN CYANIDE    HCN    T         79      [illegible]
14200 PRINT #    HYDROGEN FLUORIDE   HFX    T        152             1.#
14210 PRINT #    HYDROGEN SULFIDE    HDS    T,F      -77           16.8#
14220 PRINT #    LIQUIF. NATL. GAS   LNG    F       -258           HIGH#
14230 PRINT #    LIQUIF. PET. GAS    LPG    F        -40           HIGH#
14240 PRINT #    METHYL BROMIDE      MTB    T         40            1.8#
14250 PRINT #    METHYL CHLORIDE     MTC    F        -11      [illegible]
14260 PRINT #    OCTANE              OAN    F        255             --#
14270 PRINT #    PENTANE             PTA    F         97             .6#
14280 PRINT #    PHOSGENE            PHG    T         46             .7#
14290 PRINT #    PROPANE             PRP    F        -44            8.9#
14300 PRINT #    PROPYLENE           PPL    F        -54           10.3#
14310 PRINT #    PROPYLENE OXIDE     POX    T,F       94      [illegible]
14320 PRINT #    SULFUR DIOXIDE      SFD    T        -14            3.3#
14330 PRINT #    TOLUENE             TOL    T,F      231            .04#
14340 PRINT #    VINYL CHLORIDE      VCM    F          7            3.4#
14350 PRINT
14360 PRINT #     *-PRINCIPAL HAZARD CODES ARE---T=TOXIC, F=FLAMMABLE#
14370 PRINT
14380 PRINT #     IF THE CHEMICAL YOU WISH SIMULATED IS NOT CONTAINED IN#
14390 PRINT #THE ABOVE LIST, CALL THE VM PROJECT OFFICER FOR ASSISTANCE.#
14400 PRINT
```

FIGURE B-3 (continued)

```
14410 PRINT #    ALL THE CHEMICALS SHOWN ARE TRANSPORTEC AS LIQUIDS.#
14420 PRINT #CHEMICALS WITH BOILING POINTS GREATER THEN 100 DEGREES ARE#
14430 PRINT #GENERALLY TRANSPORTED AT AMBIENT TEMPERATURES AND PRESSURES.#
14440 PRINT #CHEMICALS WITH BOILING POINTS LESS THEN AMBIENT ARE GENERALLY#
14450 PRINT #TRANSPORTED IN ONE OF TWO CONDITIONS: REFRIGERATED OR PRESS-#
14460 PRINT #URIZED. WHEN REFRIGERATED, THEIR TEMPERATURES WILL BE SLIGHTLY#
14470 PRINT #LESS THAN THEIR BOILING POINTS AND THEIR PRESSURES SLIGHTLY#
14480 PRINT #GREATER THAN AMBIENT (I.E. APPROX. ONE ATMOSPHERE). WHEN#
14490 PRINT #PRESSURIZED, THE CHEMICALS WILL BE TRANSPORTED AT AMBIENT#
14500 PRINT #TEMPERATURES AND AT PRESSURES EQUAL TO THEIR VAPOR PRESSURE.#
14510 PRINT #IN WATER TRANSPORTATION, THE SHIPPERS TEND TOWARD REFRIGER-#
14520 PRINT #ATION RATHER THAN PRESSURIZATION. IT SHOULD BE NOTED THAT#
14530 PRINT #THERE ARE EXCEPTIONS TO THE ABOVE GENERALIZATIONS AND SOME#
14540 PRINT #CHEMICALS ARE TRANSPORTED BOTH REFRIGERATEC AND PRESSURIZED.#
14550 PRINT
14560 PRINT
14570 RETURN
14580 PRINT #    SPILLS IN CHANNELS OF THE ORDER OF 1,000 FEET IN WIDTH#
14590 PRINT #OR GREATER CAN BE CONSIDERED OPEN-WATER SPILLS UNLESS TIDAL#
14600 PRINT #OR RIVER FLOW IS TO BE SIMULATED. FOR MOST SPILL PROBLEMS,#
14610 PRINT #AN OPEN-WATER SPILL WILL PROVIDE A MORE CONSERVATIVE ESTIM-#
14620 PRINT #ATION (COMPUTES GREATER DAMAGE) THAN A CHANNEL OR RIVER SIM-#
14630 PRINT #ULATION.#
14640 PRINT
14650 PRINT #    FOR LOS ANGELES HARBOR, THE MOST SIGNIFICANT CHANNEL#
14660 PRINT #COMPLEX IS THE MAIN CHANNEL WHICH LEADS INTO THE RIVER #
14670 PRINT #HARBOR. THIS CHANNEL IS OF THE ORDER OF 800 FEET WIDE, 47#
14680 PRINT #FEET DEEP, AND HAS MODERATELY ROUGH BANKS. MEAN WATER TEM-#
14690 PRINT #PERATURES IN LOS ANGELES HARBOR VARY FROM 46 DEG. F. TO 66#
14700 PRINT #DEG. F. (SEE N.O.A.A. CHART =18749).#
14710 PRINT
14720 PRINT #    FOR NEW ORLEANS, THE PRINCIPAL CHANNEL IS THE MISSISSIPPI#
14730 PRINT #RIVER, WHICH IS OF THE ORDER OF 2,000 FEET WIDE, 60 FEET DEEP,#
14740 PRINT #WITH MODERATELY ROUGH BANKS. MEAN WATER TEMPERATURES VARY#
14750 PRINT #FROM 61 TO 85 DEG. F. RIVER VELOCITIES RANGE BETWEEN 4.7 AND#
14760 PRINT #6.4  FEET PER SECOND (SEE N.O.A.A. CHART =11369).#
14770 PRINT
14780 PRINT #    IN NEW YORK HARBOR, THERE ARE MANY CHANNELS AND RIVERS#
14790 PRINT #USED FOR BULK SHIPMENT OF CHEMICALS (SEE N.O.A.A. CHART#
14800 PRINT #=12337). ALTHOUGH RIVER FLOW IS NOT SIGNIFICANT IN THE NEW#
14810 PRINT #YORK CITY AREA, TIDAL FLOWS CAN BE AS HIGH AS 8 FEET PER SEC-#
14820 PRINT #OND. MEAN WATER TEMPERATURES RANGE FORM 35 TO 72 DEG. F. DE-#
14830 PRINT #PENDING UPON THE TIME OF YEAR.#
14840 PRINT
14850 PRINT
14860 PRINT #THE UIM WILL NOT ACCEPT WATER TEMPERATURES OUTSIDE OF THE#
14870 PRINT #RANGE -4 TO +49 DEGREES CELSIUS (25 TO 120 FAHRENHEIT).#
14880 PRINT
14890 PRINT
14900 RETURN
14910 REM #INFO SUB FOR QUESTIONS 20 TO 22#
14920 PRINT #    THE SPILL LATITUDES MUST BE GIVEN IN DEGREES, MINUTES#
14930 PRINT #AND SECONDS NORTH OF THE EQUATOR, AND THE SPILL LONGITUDE IN#
14940 PRINT #DEGREES, MINUTES AND SECONDS WEST OF GREENWICH.#
14950 PRINT
14960 PRINT #    A REFERENCE LOCATION FOR LOS ANGELES HARBOR IS THE #
14970 PRINT #ENTRANCE TO THE MAIN CHANNEL  AT--#
14980 PRINT #    LATITUDE   33 DEG. 43 MIN. 00 SEC#
14990 PRINT #    LONGITUDE 118 DEG. 16 MIN. 00 SEC.#
15000 PRINT
15010 PRINT #EACH MINUTE OF LATITUDE IS EQUIVALENT TO ONE NAUTICAL MILE#
15020 PRINT #(6080 FEET), AND AT THIS SITE EACH MINUTE OF LONGITUDE IS#
15030 PRINT #EQUIVALENT TO 5/6 OF A NAUTICAL MILE (5070 FEET) (SEE N.O.A.A.#
15040 PRINT #CHART =18749)#
15050 PRINT
```

FIGURE B-3 (continued)

```
15060 PRINT #     A REFERENCE LOCATION FOR NEW ORLEANS IS THE INTERSECTION#
15070 PRINT #OF THE HARVEY CANAL NO. 1 AND THE MISSISSIPPI RIVER, AT--#
15080 PRINT #     LATITUDE     29 DEG. 54 MIN. 44 SEC.#
15090 PRINT #     LONGITUDE    90 DEG. 05 MIN. 05 SEC.#
15100 PRINT #AT THIS SITE, EACH MINUTE OF LONGITUDE IS EQUIVALENT TO#
15110 PRINT #5280 FEET (SEE N.O.A.A. CHARTS =11369 OR 878-SC).#
15120 PRINT
15130 PRINT #     A REFERENCE LOCATION FOR NEW YORK HARBOR IS NEAR#
15140 PRINT #THE MOUTH OF THE ARTHUR KILL AT PERTH AMBOY, AT--#
15150 PRINT #     LATITUDE     40 DEG. 30 MIN. 40 SEC.#
15160 PRINT #     LONGITUDE    74 DEG. 15 MIN. 35 SEC.#
15170 PRINT #AT THIS SITE, A MINUTE OF LONGITUDE IS EQUAL TO 3/4 OF A#
15180 PRINT #NAUTICAL MILE (OR, 4,560 FEET) (SEE N.O.A.A. CHART =12337).#
15190 RETURN
15200 PRINT #     THE VM SIMULATES TWO BASIC TYPES OF HAZARDOUS CHEMICALS--#
15210 PRINT #TOXIC AND FLAMMABLE. FOR TOXIC CHEMICAL SPILLS, THE VM SIM-#
15220 PRINT #ULATES THE DEVELOPMENT OF THE SPILL, THE VAPORIZATION OF THE#
15230 PRINT #CHEMICAL, THE FORMATION OF A TOXIC CLOUD OR PLUME, THE#
15240 PRINT #MOVEMENT AND DISPERSION OF THE CLOUD, AND THE ACUTE TOXIC#
15250 PRINT #DAMAGE (DEATHS AND INJURIES) OCCURRING TO PEOPLE RESIDING#
15260 PRINT #IN THE PATH OF THE CLOUD.#
15270 PRINT
15280 PRINT #     FOR FLAMMABLE CHEMICALS, THE VM COMPUTES FIRE DAMAGE TO#
15290 PRINT #PEOPLE AND PROPERTY RESULTING FROM THREE TYPES OF FIRE HAZARDS--#
15300 PRINT #POOL BURNING, FIREBALL AND FLASH FIRE. POOL BURNING OCCURS#
15310 PRINT #WHEN AN IMMISCIBLE FLAMMABLE LIQUID IS SPILLED AND CATCHES ON#
15320 PRINT #FIRE AT THE SPILL SITE WHILE IT IS STILL IN THE FORM OF A#
15330 PRINT #FLOATING POOL OF LIQUID.#
15340 PRINT
15350 PRINT #     A FIREBALL OCCURS WHEN A PRESSURIZED GAS OR HIGHLY#
15360 PRINT #VOLATILE LIQUID IS IGNITED AS IT ESCAPES, BURSTING THE TANK#
15370 PRINT #AND GENERATING A HIGHLY COMBUSTIBLE MIXTURE OF MATERIAL AND#
15380 PRINT #AIR WHICH BURNS VERY RAPIDLY AND FORMS A FIREBALL. THE FIRE-#
15390 PRINT #BALL HAZARD IS COMMON FOR SPILL INCIDENTS INVOLVING PROPANE.#
15400 PRINT
15410 PRINT #     FLASH FIRE OCCURS FOR VOLATILE CHEMICAL SPILLS WHICH DO NOT#
15420 PRINT #CATCH FIRE AT THE SPILL SITE (DUE TO LACK OF AN IGNITION#
15430 PRINT #SOURCE) BUT FORM FLAMMABLE VAPOR CLOUDS WHICH ARE BLOWN DOWN-#
15440 PRINT #WIND AND ARE IGNITED AT SOME DISTANCE FROM THE SPILL SITE.  THE#
15450 PRINT #FLASH FIRE HAZARD CAN BE THE MOST SERIOUS BECAUSE IT INVOLVES#
15460 PRINT #THE TRANSPORT OF THE HAZARDOUS MATERIAL FROM THE SPILL SITE#
15470 PRINT #TO DOWNWIND AREAS THAT CAN BE MUCH MORE POPULATED THAN THE #
15480 PRINT #SPILL SITE.  IF, AT THE TIME OF IGNITION, ALL OF THE SPILLED#
15490 PRINT #LIQUID HAS NOT BEEN VAPORIZED, THEN POOL BURNING OCCURS IN #
15500 PRINT #ADDITION TO FLASH FIRE. ALSO, THE POSSIBILITY EXISTS THAT#
15510 PRINT #UNDER CERTAIN CONDITIONS THE HIGHLY COMBUSTIBLE VAPOR CLOUD#
15520 PRINT #CAN EXPLODE RATHER THAN BURN.  HENCE, THE VM SIMULATES THE EX-#
15530 PRINT #PLOSION OF THE VAPOR CLOUD IN ADDITION TO FLASH FIRE AND COM-#
15540 PRINT #PUTES THE EXPLOSION DAMAGE TO PEOPLE AND PROPERTY AS WELL AS#
15550 PRINT #FLASH FIRE DAMAGE. THE USER IS CAUTIONED THAT IN ALL CASES#
15560 PRINT #INVOLVING UNCONFINED FLAMMABLE VAPOR CLOUDS, FLASH FIRE IS MUCH#
15570 PRINT #MORE LIKELY TO OCCUR THAN EXPLOSION. HOWEVER, EXPLOSION IS IN-#
15580 PRINT #CLUDED AS A WORST-CASE CONSIDERATION, EVEN THOUGH IT IS RECOG-#
15590 PRINT #NIZED TO BE A REMOTE POSSIBILITY IN MOST SPILL SITUATIONS.#
15600 PRINT
15610 PRINT
15620 RETURN
```

FIGURE B-3 (continued)

```
15630 PRINT #     THE VM IS DESIGNED TO SIMULATE THE CONSEQUENCES OF#
15640 PRINT #HAZARDOUS MATERIAL SPILLS AT SPECIFIED PORTS, HARBORS, OR#
15650 PRINT #OTHER MARINE LOCATIONS. TO DO THIS, THE USER MUST SPECIFY THE#
15660 PRINT #LOCATION AND CHARACTERISTICS OF THE VULNERABLE RESOURCES IN#
15670 PRINT #THE VICINITY  OF THE SPILL SITE. THIS IS ACCOMPLISHED BY#
15680 PRINT #MEANS OF A GEOGRAPHICAL/DEMOGRAPHICAL FILE WHICH DIVIDES THE#
15690 PRINT #AREA OF INTEREST INTO CELLS AND GIVES THE LOCATION, NUMBER OF#
15700 PRINT #PEOPLE, AND NUMBER AND VALUE OF BUILDINGS FOR EACH CELL.#
15710 PRINT #THERE ARE FIVE GEOGRAPHICAL/DEMOGRAPHICAL FILES PRESENTLY#
15720 PRINT #EXISTING IN THE UIM/VM SYSTEM. THESE ARE--#
15730 PRINT
15740 PRINT #            FILE       NUMBER          #
15750 PRINT #PORT        NUMBER     OF CELLS             AREA COVERED#
15760 PRINT #----        ------     --------     -------------------------#
15770 PRINT #L.A.         1611        362        PALO VERDE TO HUNT'N BCH, ALONG HARBOR#
15780 PRINT #N.O.         2211        336        FROM METAIRIE TO ARABI#
15790 PRINT #N.Y.         3611        384        RADIAL DIST. OF 7 MI. ARND. PERTH AMBOY#
15800 PRINT #N.Y.         3612        386        CONEY ISL. AND SOUTH BROOKLYN#
15810 PRINT
15820 PRINT
15830 PRINT #     APPENDIX C OF THE UIM USER'S GUIDE PRESENTS MAPS OF THESE#
15840 PRINT #FILES SHOWING THE PRECISE AREA COVERED BY THE FILE AND WHERE#
15850 PRINT #EACH CELL IS LOCATED. BY PLOTTING THE SPILL LOCATION AND THE#
15860 PRINT #WIND DIRECTION, THE USER CAN DETERMINE WHICH GEOGRAPHICAL FILE#
15870 PRINT #IS APPLICABLE. IF THE AREA THE USER IS INTERESTED IN IS NOT#
15880 PRINT #COVERED BY AN EXISTING FILE, THE USER SHOULD CALL THE VM#
15890 PRINT #PROJECT OFFICER FOR ASSISTANCE.#
15900 PRINT
15910 PRINT #     ASSOCIATED WITH EACH GEOGRAPHICAL/DEMOGRAPHICAL FILE IS A#
15920 PRINT #SECONDARY FIRE FILE. THESE ARE LISTINGS OF CELLS WHICH CONTAIN#
15930 PRINT #STORAGE TANKS OR WAREHOUSES OF FLAMMABLE MATERIALS WHICH, IF#
15940 PRINT #IGNITED BY THE PRIMARY FIRE HAZARD, WILL CAUSE FIRE DAMAGE TO#
15950 PRINT #THE VULNERABLE RESOURCES IN THE VICINITY OF THE SECONDARY FIRE#
15960 PRINT #SOURCE. THE USER HAS THE OPTION OF USING THIS FILE OR NOT.#
15970 PRINT
15980 PRINT
15990 PRINT #     THE USER MUST SPECIFY THE FRACTION OF THE PEOPLE SHELTERED#
16000 PRINT #FROM EITHER TOXIC OR THERMAL EFFECTS. IN THE CASE OF TOXIC#
16010 PRINT #DAMAGE, THE SHELTERED PEOPLE ARE ASSUMED TO BE INDOORS AND THERE-#
16020 PRINT #FORE SUBJECTED TO LESS TOXIC CONCENTRATION THAN PEOPLE OUTDOORS.#
16030 PRINT #FOR FIRE DAMAGE, THE SHELTERED PEOPLE ARE ASSUMED TO BE SHIELDED#
16040 PRINT #FROM THERMAL RADIATION BY WALLS OR BY STRUCTURES AND DO NOT RE-#
16050 PRINT #CEIVE INJURIOUS LEVELS OF RADIATION. A CONSERVATIVE VALUE FOR#
16060 PRINT #FRACTION SHELTERED IS .50. FOR THERMAL DAMAGE THIS VALUE IS PROBA-#
16070 PRINT #BLY TOO LOW BECAUSE SOME OF THE PEOPLE OUTSIDE AS WELL AS ALL OF#
16080 PRINT #THE PEOPLE INSIDE WILL BE SHIELDED. A VALUE OF .75 IS PROBABLY#
16090 PRINT #A MORE APPROPRIATE VALUE FOR THERMAL DAMAGE CASES.#
16100 PRINT
16110 RETURN
16120 REM #PUT THE INFORMATION SUBROUTINE FOR QUESTIONS 37-35 HERE#.
16130 PRINT #     IN COMPUTING DAMAGE FOR THE VARIOUS CELLS, THE VM MAKES#
16140 PRINT #COMPUTATIONS AT SIMULATED TIMES SPECIFIED BY THE USER. THREE#
16150 PRINT #INPUTS ARE NEEDED TO SPECIFY A TIME SEQUENCE-- THE TIME THAT#
16160 PRINT #THE COMPUTATIONS ARE TO BEGIN, THE TIME THAT THE COMPUTATIONS ARE#
16170 PRINT #TO END, AND THE TIME INTERVAL BETWEEN CALCULATIONS. THREE TIME#
16180 PRINT #SEQUENCES ARE AVAILABLE IN THE VM TO ALLOW THE USER FLEXIBILITY#
16190 PRINT #IN HANDLING DIFFERENT PROBLEMS. THE FIRST TIME SEQUENCE IS SPE-#
16200 PRINT #CIFIED IN UNITS OF SECONDS AND IS USED IN POOL BURNING OR FIREBALL#
16210 PRINT #PROBLEMS WHERE IGNITION OCCURS QUITE SOON AFTER THE SPILL. THE#
16220 PRINT #SECOND AND THIRD TIME SEQUENCES ARE IN UNITS OF MINUTES. THESE ARE#
16230 PRINT # USED IN TOXIC DAMAGE OR FLASH FIRE PROBLEMS INVOLVING THE DOWN-#
16240 PRINT #WIND TRANSPORT OF THE HAZARDOUS VAPOR CLOUD. ORDINARILY, ONLY ONE#
16250 PRINT #TIME SEQUENCE IS NEEDED FOR THESE PROBLEMS, AND A RECOMMENDED#
16260 PRINT #SEQUENCE IS AS FOLLOWS--#
16270 PRINT #                         T-BEGIN = 2 MINUTES#
16280 PRINT #                         T-END   =90 MINUTES#
16290 PRINT #                         T-DELTA = 2 MINUTES#
16300 PRINT
```

FIGURE B-3 (continued)

```
16310 PRINT *HOWEVER, IN CASES WHERE THE VAPOR CLOUD MAY TRAVEL OVER LARGE*
16320 PRINT *DISTANCES WHERE NO VULNERABLE RESOURCES EXIST, SUCH AS THE CASE*
16330 PRINT *OF A SPILL OCCURRING SEVERAL MILES FROM SHORE, THE USER WILL*
16340 PRINT *CONSERVE COMPUTER TIME BY USING TWO TIME SEQUENCES, I.E., BOTH*
16350 PRINT *THE SECOND AND THE THIRD. IN THIS CASE, THE SECOND SEQUENCE*
16360 PRINT *WOULD BE SPECIFIED FOR THE TIME IT TAKES THE VAPOR CLOUD TO REACH*
16370 PRINT *SHORE AND INFREQUENT CALCULATIONS WOULD BE SPECIFIED. THEN, THE*
16380 PRINT *THIRD SEQUENCE WOULD BE USED TO SPECIFY THE FREQUENCY OF CALCU-*
16390 PRINT *LATIONS AFTER THE CLOUD REACHES THE SHORE AND MORE FREQUENT CAL-*
16400 PRINT *CULATIONS NORMALLY USED FOR POPULATED REGIONS WOULD BE SPECIFIED,*
16410 PRINT *E.G., EVERY 2 MINUTES.*
16420 PRINT
16430 PRINT *     THE UIM HAS AUTOMATICALLY SPECIFIED AN INFREQUENT TIME*
16440 PRINT *SEQUENCE OVER WATER AND A 2-MINUTE SEQUENCE OVER LAND FOR YOUR*
16450 PRINT *PROBLEM. IF YOU WISH TO CHANGE THIS TIME SEQUENCE, ENTER INPUT*
16460 PRINT *OTHERWISE, ENTER NO.*
16470 PRINT
16480 RETURN
16490 REM *THIS SUB USED FOR OUTPUT TO A FILE*
16500 D=1
16510 IF V$=*NEW* THEN 16530
16520 D=3
16530 FILE #D=D$
16540 PRINT #D USING 16550,*UIM INPUT*,N1$,N2$
16550 : #########   #################################  #########,
16560 PRINT #D
16570 PRINT #D USING 16580,M1$,M1$
16580 :1001 ###              ,###,
16590 PRINT #D USING 16600,Z(1,24),Z(2,24),Z(2,22)
16600 :  ## ####              #####.##
16610 PRINT #D USING 16620,Z(1,120),F1
16620 :  ##                   #
16630 PRINT #D USING 16640,Z(1,121),D3
16640 :  ##                   #
16650 PRINT #D USING 16660,Z(1,4),Z(3,4),Z(2,4)
16660 :#### #.#####↑↑↑↑       #######.##
16670 PRINT #D USING 16680,Z(1,5),Z(3,5),Z(2,5)
16680 :#### #####.#           ###.##
16690 PRINT #D USING 16700,Z(1,9),Z(3,9),Z(2,9)
16700 :#### ####.#            ###.##
16710 PRINT #D USING 16720,Z(1,2),Z(3,2),Z(2,2)
16720 :#### ####.##           ####.##
16730 PRINT #D USING 16740,Z(1,3),Z(3,3),Z(2,3)
16740 :#### #.#####↑↑↑↑       ###
16750 PRINT #D USING 16760,Z(1,135),Z(3,135)
16760 :#### #.
16770 PRINT #D USING 16780,Z(1,6),Z(3,6),Z(2,6)
16780 :#### #.#####↑↑↑↑       #.##
16790 PRINT #D USING 16800,Z(1,7),Z(3,7),Z(2,7)
16800 :#### #.#####↑↑↑↑       ###.##
16810 PRINT #D USING 16820,Z(1,137),Z(3,137)
16820 :#### #.#####↑↑↑↑
16830 PRINT #D USING 16840,Z(1,8),Z(3,8),Z(2,8)
16840 :#### ####.             ####.##
16850 PRINT #D USING 16860,Z(1,16),Z(3,16),Z(2,16)
16860 :#### ####.             ###.##
16870 PRINT #D USING 16880,Z(1,19),Z(3,19),M6$
16880 :#### #.                #.
16890 PRINT #D USING 16900,Z(1,10),Z(3,10),Z(2,10)
16900 :####                   #.  #
16910 IF Z(2,10)=1 THEN 16940
16920 PRINT #D USING 16930,Z(1,12),Z(3,12),Z(2,12)
16930 :#### #.#####↑↑↑↑       ####.##
16940 PRINT #D USING 16950,Z(1,138),Z(3,138)
16950 :####                #.
```

FIGURE 8-3 (continued)

```
16960 PRINT ≡D USING 16970,Z(1,11),Z(3,11),Z(2,11)
16970 :≡≡≡≡ ≡≡≡.≡≡          ≡≡≡.≡≡
16980 PRINT ≡D USING 16990,Z(1,139),Z(3,139)
16990 :≡≡≡≡ ≡≡≡≡.≡≡≡
17000 PRINT ≡D USING 17010,Z(1,101),Z(3,101)
17010 :≡≡≡≡          ≡.
17020 PRINT ≡D USING 17030,Z(1,102),Z(3,102)
17030 :≡≡≡≡          ≡.
17040 PRINT ≡D USING 17050,Z(1,140),Z(3,140)
17050 :≡≡≡≡ ≡≡≡≡.
17060 PRINT ≡D USING 17070,Z(1,103),Z(3,103)
17070 :≡≡≡≡ ≡≡≡≡.≡≡
17080 PRINT ≡D USING 17090,Z(1,141),Z(3,141)
17090 :≡≡≡≡ ≡≡≡≡≡≡.≡≡≡
17100 IF Z(2,10)=1 THEN 17150
17110 PRINT ≡D USING 17120,Z(1,13),Z(3,13),Z(2,13)
17120 :≡≡≡≡ ≡≡≡≡.         ≡≡≡≡.≡≡
17130 PRINT ≡D USING 17140,Z(1,104),Z(3,104)
17140 :≡≡≡≡ ≡.≡≡≡≡%%%%
17150 PRINT ≡D USING 17160,Z(1,142),Z(3,142)
17160 :≡≡≡≡ ≡.≡
17170 IF Z(2,10)=1 THEN 17220
17180 PRINT ≡D USING 17190,Z(1,14),Z(3,14),Z(2,14)
17190 :≡≡≡≡ ≡≡≡≡.≡          ≡≡.≡≡
17200 PRINT ≡D USING 17210,Z(1,15),Z(3,15),Z(2,15)
17210 :≡≡≡≡          ≡.   ≡
17220 PRINT ≡D USING 17230,Z(1,18),Z(3,18),Z(2,18)
17230 :≡≡≡≡ ≡≡≡≡.≡≡         ≡≡≡≡.≡≡
17240 PRINT ≡D USING 17250,Z(1,17),Z(3,17),Z(2,17)
17250 :≡≡≡≡ ≡≡≡.≡≡          ≡≡≡.≡
17260 PRINT ≡D USING 17270,Z(1,25),Z(3,25),Z(2,25)
17270 :≡≡≡≡          ≡.   ≡
17280 PRINT ≡D USING 17290,Z(1,143),Z(3,143)
17290 :≡≡≡≡          ≡.
17300 PRINT ≡D USING 17310,Z(1,23),Z(3,23),Z(2,23)
17310 :≡≡≡≡          ≡.   ≡
17320 PRINT ≡D USING 17330,Z(1,105),Z(3,105),M5$
17330 :≡≡≡≡          ≡.   >≡≡≡,
17340 PRINT ≡D USING 17350,Z(1,106),Z(3,106)
17350 :≡≡≡≡          ≡.
17360 PRINT ≡D USING 17370,Z(1,147),Z(3,147)
17370 :≡≡≡≡ ≡≡≡.
17380 PRINT ≡D USING 17390,Z(1,155),Z(3,155)
17390 :≡≡≡≡ ≡≡≡≡.≡
17400 FOR K=148 TO 154
17410 PRINT ≡D USING 17420,Z(1,K),Z(3,K)
17420 :≡≡≡≡ ≡≡≡≡.≡≡≡≡
17430 NEXT K
17440 PRINT ≡D USING 17450,Z(1,26),Z(3,26),Z(2,26)
17450 :≡≡≡≡ ≡.≡≡          ≡.≡≡
17460 FOR K=27 TO 35
17470 PRINT ≡D USING 17480,Z(1,K),Z(3,K),Z(2,K)
17480 :≡≡≡≡ ≡≡≡≡.         ≡≡≡≡.
17490 NEXT K
17500 PRINT ≡D USING 17510,Z(1,20),L$(1),L$(1)
17510 :≡≡≡≡ ≡≡≡≡≡≡≡≡≡≡     ,≡≡≡≡≡≡≡≡≡≡,
17520 PRINT ≡D USING 17530,Z(1,21),L$(2),L$(2)
17530 :≡≡≡≡ ≡≡≡≡≡≡≡≡≡≡     ,≡≡≡≡≡≡≡≡≡≡,
17540 PRINT ≡D
17550 IF D=3 THEN 17640
17560 D1$=≠SAVE,≠+D$
17570 CLOSE ≡D: D1$
17580 PRINT ≠A NEW FILE HAS BEEN SAVED FOR YOU≠
17590 PRINT USING 17600,D$
17600 :THE NAME OF THE NEW FILE IS ≡≡≡≡≡≡
17610 PRINT ≠PLEASE REMEMBER IT FOR FURTHER USE.≠
17620 PRINT
17630 RETURN
```

FIGURE B-3 (continued)

```
17640 REM ≠PROCEDURE TO SAVE THE NEW AND OLD FILES.≠
17650 D1$=≠SAVE,≠+D$
17660 CLOSE ≡0: D1$
17670 CLOSE ≡2
17680 PRINT ≠THE NEW FILE HAS BEEN SAVED. ITS NAME IS ≠;C$;≠.≠
17690 PRINT ≠THE ORIGINAL FILE STILL EXISTS. ITS NAME IS STILL ≠;E$;≠.≠
17700 PRINT
17710 RETURN
17720 PRINT ≠THIS FILE ALREADY EXISTS ON DISK.≠
17730 GOTO 09270
17740 REM ≠SUB USED TO GENER NAME≠
17750 DATA A,B,C,D,E,F,G,H,I,J,K,L,M,N,O,P,Q,R,S,T,U,V,W,X,Y,Z
17760 DIM A1$(26)
17770 MAT READ A1$
17780 DIM A2$(6)
17790 FOR I=1 TO 6
17800 A2$(I)=A1$(INT(((RND(-3)*25)+1)))
17810 NEXT I
17820 F8=1
17830 D$=A2$(1)+A2$(2)+A2$(3)+A2$(4)+A2$(5)+A2$(6)
17840 RETURN
17850 REM ≠THIS PROCEDURE USED TO INPUT AN EXISTING FILE≠
17860 D$=≠DUMMYF≠
17870 D=2
17880 PRINT
17890 PRINT ≠WHAT IS THE NAME OF THE FILE THAT YOU WISH TO LOAD.≠
17900 INPUT D$
17910 IF D$=≠STOP≠ THEN 19900
17920 IF LEN(D$)=6 THEN 17980
17930 PRINT ≠THOSE FILE ACCESSABLE BY THE UIM ARE ONLY THOSE CREATED≠
17940 PRINT ≠BY THE UIM. THOSE FILES CREATED BY THE UIM ARE SIX(6)≠
17950 PRINT ≠CHARACTERS IN LENGTH. PLEASE RETYPE YOUR ANSWER. YOU≠
17960 PRINT ≠TERMINATE THE PROGRAM BY ANSWERING STOP.≠
17970 GOTO 17900
17980 FILE ≡0: ≠GET,≠+D$
17990 PRINT
18000 PRINT ≠PLEASE WAIT WHILE I LOAD YOUR FILE.≠
18010 INPUT ≡0,F$
18020 INPUT ≡0,F,F1$,H1$
18030 W$=H1$
18040 GOSUB 11930
18050 INPUT ≡0,Z(1,24),Z(2,24),Z(2,22)
18060 INPUT ≡0,Z(1,120),F1
18070 F5=1
18080 GOTO 01060
18090 INPUT ≡0,Z(1,121),B3
18100 IF B3=0 THEN 18130
18110 B3$=≠YES≠
18120 GOTO 18140
18130 B3$=≠NO≠
18140 INPUT ≡0,Z(1,4),Z(3,4),Z(2,4)
18150 REM ≠UNITS AND CHEMICAL PROPERTIES SET!≠
18160 INPUT ≡0,Z(1,5),Z(3,5),Z(2,5)
18170 INPUT ≡0,Z(1,9),Z(3,9),Z(2,9)
18180 INPUT ≡0,Z(1,2),Z(3,2),Z(2,2)
18190 INPUT ≡0,Z(1,3),Z(3,3),Z(2,3)
18200 INPUT ≡0,Z(1,135),Z(3,135)
18210 INPUT ≡0,Z(1,6),Z(3,6),Z(2,6)
18220 INPUT ≡0,Z(1,7),Z(3,7),Z(2,7)
18230 INPUT ≡0,Z(1,137),Z(3,137)
18240 INPUT ≡0,Z(1,8),Z(3,8),Z(2,8)
18250 INPUT ≡0,Z(1,16),Z(3,16),Z(2,16)
18260 INPUT ≡0,Z(1,19),Z(3,19),M9$
18270 INPUT ≡0,Z(1,10),Z(3,10),Z(2,10)
18280 IF Z(2,10)=1 THEN 18300
```

FIGURE B-3 (continued)

```
18290 INPUT ≡D,Z(1,12),Z(3,12),Z(2,12)
18300 INPUT ≡D,Z(1,138),Z(3,138)
18310 INPUT ≡D,Z(1,11),Z(3,11),Z(2,11)
18320 INPUT ≡D,Z(1,139),Z(3,139)
18330 INPUT ≡D,Z(1,101),Z(3,101)
18340 INPUT ≡D,Z(1,102),Z(3,102)
18350 INPUT ≡D,Z(1,140),Z(3,140)
18360 INPUT ≡D,Z(1,103),Z(3,103)
18370 INPUT ≡D,Z(1,141),Z(3,141)
18380 IF Z(2,10)=1 THEN 18410
18390 INPUT ≡D,Z(1,13),Z(3,13),Z(2,13)
18400 INPUT ≡D,Z(1,104),Z(3,104)
18410 INPUT ≡D,Z(1,142),Z(3,142)
18420 IF Z(2,10)=1 THEN 18450
18430 INPUT ≡D,Z(1,14),Z(3,14),Z(2,14)
18440 INPUT ≡D,Z(1,15),Z(3,15),Z(2,15)
18450 INPUT ≡D,Z(1,18),Z(3,18),Z(2,18)
18460 INPUT ≡D,Z(1,17),Z(3,17),Z(2,17)
18470 INPUT ≡D,Z(1,25),Z(3,25),Z(2,25)
18480 INPUT ≡D,Z(1,143),Z(3,143)
18490 INPUT ≡D,Z(1,23),Z(3,23),Z(2,23)
18500 INPUT ≡D,Z(1,105),Z(3,105),MS$
18510 INPUT ≡D,Z(1,106),Z(3,106)
18520 INPUT ≡D,Z(1,147),Z(3,147)
18530 INPUT ≡D,Z(1,155),Z(3,155)
18540 FOR K=148 TO 154
18550 INPUT ≡D,Z(1,K),Z(3,K)
18560 NEXT K
18570 INPUT ≡D,Z(1,26),Z(3,26),Z(2,26)
18580 FOR K=27 TO 35
18590 INPUT ≡D,Z(1,K),Z(3,K),Z(2,K)
18600 NEXT K
18610 INPUT ≡D,Z(1,20),F$,L$(1)
18620 INPUT ≡D,Z(1,21),F$,L$(2)
18630 PRINT
18640 PRINT ≠FILE IS NOW LOADED.≠
18650 RESTORE ≡D
18660 GOSUB 19910
18670 PRINT
18680 IF K$<>≠YES≠ THEN 07900
18690 IF F1=1 THEN 18730
18700 PRINT ≠THE FILE LOADED WAS CREATED USING MKS UNITS.≠
18710 PRINT ≠ONLY MKS UNITS CAN BE USED DURING EDITING.≠
18720 GO TO 07900
18730 PRINT ≠THE FILE LOADED WAS CREATED USING BRITISH UNITS.≠
18740 PRINT ≠ONLY BRITISH UNITS CAN BE USED DURING EDITING.≠
18750 GOTO 07900
18760 PRINT
18770 PRINT ≠LOADING ≠ID$≠...≠
18780 F6=2
18790 GOTO 18010
18800 REM ≠BRANCH TO BUILD A VM-ACCEPTABLE DATA FILE.≠
18810 D=4
18820 FILE ≡D=≠VMINPUT≠
18830 PRINT ≡D,N1$,N2$
18840 PRINT ≡D,≠  ≠
18850 PRINT ≡D,≠1001≠M1$
18860 PRINT ≡D USING 18870,Z(1,4),Z(3,4)
18870 :≡≡≡≡ .≡≡≡≡↑↑↑↑
18880 PRINT ≡D USING 18890,Z(1,5),Z(3,5)
18890 :≡≡≡≡ ≡≡≡≡≡.≡
18900 PRINT ≡D USING 18910,Z(1,9),Z(3,9)
18910 :≡≡≡≡ ≡≡≡≡≡.≡
18920 PRINT ≡D USING 18930,Z(1,2),Z(3,2)
18930 :≡≡≡≡ ≡≡≡≡.≡≡
18940 PRINT ≡D USING 18950,Z(1,3),Z(3,3)
18950 :≡≡≡≡ .≡≡≡≡↑↑↑↑
```

FIGURE B-3 (continued)

```
18960 PRINT #0 USING 18970,Z(1,135),Z(3,135)
18970 :#### #.
18980 PRINT #0 USING 18990,Z(1,6),Z(3,6)
18990 :#### .####^^^^
19000 PRINT #0 USING 19010,Z(1,7),Z(3,7)
19010 :#### .####^^^^
19020 PRINT #0 USING 19030,Z(1,137),Z(3,137)
19030 :#### .####^^^^
19040 PRINT #0 USING 19050,Z(1,8),Z(3,8)
19050 :#### .####^^^^
19060 PRINT #0 USING 19070,Z(1,16),Z(3,16)
19070 :#### .####^^^^
19080 PRINT #0 USING 19090,Z(1,19),Z(3,19)
19090 :#### #.
19100 PRINT #0 USING 19110,Z(1,10),Z(3,10)
19110 :#### #.
19120 IF Z(2,10)=1 THEN 19150
19130 PRINT #0 USING 19140,Z(1,12),Z(3,12)
19140 :#### .####^^^^
19150 PRINT #0 USING 19160,Z(1,138),Z(3,138)
19160 :#### #.
19170 PRINT #0 USING 19180,Z(1,11),Z(3,11)
19180 :#### ###.##
19190 PRINT #0 USING 19200,Z(1,139),Z(3,139)
19200 :#### ###.####
19210 PRINT #0 USING 19220,Z(1,101),Z(3,101)
19220 :#### #.
19230 PRINT #0 USING 19240,Z(1,102),Z(3,102)
19240 :#### #.
19250 PRINT #0 USING 19260,Z(1,140),Z(3,140)
19260 :#### ####.
19270 PRINT #0 USING 19280,Z(1,103),Z(3,103)
19280 :#### ####.##
19290 PRINT #0 USING 19300,Z(1,141),Z(3,141)
19300 :#### .####^^^^
19310 IF Z(2,10)=1 THEN 19360
19320 PRINT #0 USING 19330,Z(1,13),Z(3,13)
19330 :#### ####.
19340 PRINT #0 USING 19350,Z(1,104),Z(3,104)
19350 :#### .####^^^^
19360 PRINT #0 USING 19370,Z(1,142),Z(3,142)
19370 :#### #.#
19380 IF Z(2,10)=1 THEN 19430
19390 PRINT #0 USING 19400,Z(1,14),Z(3,14)
19400 :#### ####.#
19410 PRINT #0 USING 19420,Z(1,15),Z(3,15)
19420 :#### #.
19430 PRINT #0 USING 19440,Z(1,18),Z(3,18)
19440 :#### ####.##
19450 PRINT #0 USING 19460,Z(1,17),Z(3,17)
19460 :#### ###.##
19470 IF M5$="YES" AND G$<>"SFBLANK" THEN 19490
19480 G$="SFBLANK"
19490 PRINT #0 USING 19500,Z(1,25),Z(3,25)
19500 :#### #.
19510 PRINT #0 USING 19520,Z(1,143),Z(3,143)
19520 :#### #.
19530 PRINT #0 USING 19540,Z(1,23),Z(3,23)
19540 :#### #.
19550 PRINT #0 USING 19560,Z(1,105),Z(3,105)
19560 :#### #.
19570 IF Z(2,23)=4 THEN 19600
19580 PRINT #0 USING 19590,Z(1,106),Z(3,106)
19590 :#### #.
19600 PRINT #0 USING 19610,Z(1,147),Z(3,147)
19610 :#### ###.
```

FIGURE B-3 (continued)

```
19620 PRINT #D USING 19630,Z(1,146),Z(3,146)
19630 :#### #.
19640 IF Z(3,155)=999 THEN 19670
19650 PRINT #D USING 19660,Z(1,155),Z(3,155)
19660 :#### ####.#
19670 FOR K=148 TO 154
19680 PRINT #D USING 19690,Z(1,K),Z(3,K)
19690 :#### ####.###
19700 NEXT K
19710 PRINT #D USING 19720,Z(1,26),Z(3,26)
19720 :#### #.##
19730 FOR K=27 TO 35
19740 PRINT #D USING 19750,Z(1,K),Z(3,K)
19750 :#### ####.
19760 NEXT K
19770 PRINT #D USING 19780,Z(1,20),L$(1)
19780 :#### #########
19790 PRINT #D USING 19800,Z(1,21),L$(2)
19800 :#### #########
19810 PRINT #D
19820 CLOSE #D
19830 FILE #15: *GET,*+F$
19840 CLOSE #15
19850 IF G$=*SFBLANK* THEN 19880
19860 FILE #16: *GET,*+G$
19870 CLOSE #16
19880 PRINT
19890 PRINT *THANK YOU FOR USING THE UIM.*
19900 STOP
19910 IF Z(2,24)<>3611 THEN 19950
19920 F$=*GEONY4*
19930 G$=*SECNY4*
19940 GOTO 20150
19950 IF Z(2,24)<>3612 THEN 19990
19960 F$=*GEONY6*
19970 G$=*SFBLANK*
19980 GOTO 20150
19990 IF Z(2,24)<>1611 THEN 20030
20000 F$=*GEOLA1*
20010 G$=*SFBLANK*
20020 GOTO 20150
20030 IF Z(2,24)<>1612 THEN 20070
20040 F$=*GEOLA2*
20050 G$=*SFBLANK*
20060 GOTO 20150
20070 IF Z(2,24)<> 2211 THEN 20110
20080 F$=*GEONC1*
20090 G$=*SECFRE*
20100 GOTO 20150
20110 PRINT *THIS GEOGRAPHIC FILE DOES NOT EXIST.*
20120 PRINT *PLEASE RE-ENTER THIS VALUE, OR TYPE*
20130 PRINT *THE WORD STOP TO END THE PROGRAM.*
20140 G4=1
20150 RETURN
```

FIGURE B-3 (concluded)

Appendix C

DERIVATION OF PROBIT COEFFICIENTS

Appendix C

DERIVATION OF PROBIT COEFFICIENTS

Fourteen toxic chemicals are incorporated in the UIM. These consist of seven chemicals for which probits had been previously derived and seven new toxic chemicals for which probit equations had to be developed. For the previously derived chemicals, all probit equations were reviewed and changes were made where errors were found or where new data could be utilized. For the new chemicals, toxic effects literature was researched and probit coefficients were derived from available dose-response data, using logical extrapolations and inferences where necessary.

The probit methodology is discussed on pages 77 to 90 of Eisenberg et al. (1975) (reference [1] of this report) and can be found in numerous toxicology or mathematical textbooks.

Table C-1 presents the probit coefficients derived for the 14 chemicals. Presented are the concentration exponent (n), the constant (a), and the slope (b) of the probit equation:

$$Pr = a + b \ln \int_{t_e} C^n dt$$

where: Pr = probit value
C = concentration (function of time)
t_e = time of exposure

Also presented are the irritation thresholds.

The dose effects data on which each of the probit derivations is based are summarized in the following paragraphs. Much of the data represents expert judgment of specialists after review of the existing dose-response data for animals and humans.

TABLE C-1

Probit Coefficients for Toxic Chemical Lethality
(concentration in ppm, time in minutes)

Chemical	Exponent of Concentration (n)	Constant (a)	Slope (b)	Irritation Threshold (ppm)
Acrolein	1.00	-9.9315	2.0488	0.26
Acrylonitrile	1.43	-29.4224	3.008	None
Ammonia	1.36	-28.33	2.27	100
Carbon tetrachloride	2.50	-6.29	0.408	None
Chlorine*	2.64	-36.45	3.13	3.4
Hydrogen chloride	1.00	-16.85	2.00	10
Hydrogen cyanide	1.43	-29.4224	3.008	None
Hydrogen fluoride*	1.00	-25.8689	3.3545	32
Hydrogen sulfide	1.43	-31.42	3.008	70
Methyl bromide	1.00	-56.81	5.27	None
Phosgene	1.00	-19.2736	3.6861	5
Propylene oxide	2.00	-7.415	0.509	None
Sulfur dioxide	1.00	-15.670	2.10	5
Toluene	2.50	-6.794	0.408	None

*Injury probits are available for chlorine and hydrogen fluoride only. The probit coefficients for injuries are as follows:

	Exponent	Constant	Slope
Chlorine	1.00	-2.40	2.90
Hydrogen fluoride	1.00	2.797	2.90

ACROLEIN

The dose-response data used for generating the probit coefficients are presented below. The data were extracted from the table for acrolein on page 88 of Rausch et al. (1977) (reference [2] of this report).

% Deaths	Exposure (minutes)	Concentration (ppm)
3	45	14.76
	15	42.18
	5	126.53
50	90	14.76
	45	42.18
	10	126.53
97	90	42.18
	22.5	126.53

ACRYLONITRILE

Acrylonitrile is a liquid; boiling point, 77.3°C; % by weight in saturated air, 14.5; solubility in water, 7.3%.

An unsuccessful search for useful dose-response data was made, and it appears that even a substantial further effort is unlikely to pay off. However, we can make a reasonable estimate of human response to acute exposure at high concentrations because acrylonitrile is toxicologically similar to hydrogen cyanide (HCN), and a similar type of response can be expected. The problem then is to estimate relative numbers.

The complicating factors are:

- HCN gives far from constant effects for a given dose (Ct) over various exposure times; the reason is rapid detoxification to SCN' and presumably acrylonitrile is the same. (See the table in the Hydrogen Cyanide section below, where the LCt_{50}* for 30 minutes is 10 times that for 0.5 minute.)
- The CN of acrylonitrile may not be as immediately available in vivo (though the literature is unclear on this), and so the detoxification may have more opportunity to occur. (We propose to ignore this: we have no way to allow for it, and not doing so will avoid possible underestimation of casualties.)

*LCt_{50} is the dose (concentration times time) which results in 50% deaths.

Lethal exposures to acrylonitrile from Patty (1962) are:

Rat	1.38 mg/liter
Rabbit	0.56 mg/liter
Cat	0.46 mg/liter
Guinea pig	1.25 mg/liter
Dog	0.18 mg/liter

These are not to be regarded as LC_{50}* values and times are lacking or not explicit, so we have no LCt values. Note that the dog is most sensitive, as for HCN. Omitting the dog, we have a value of roughly 1 mg/liter or 1,000 mg m^{-3}. This is equivalent to about 500 mg/liter of HCN (on an equal CN basis). The concentration of HCN estimated for LCt_{50} in man is:

Time (minutes)	Concentration (mg m^{-3})
1	3,406
3	1,467
10	607
30	687

We don't know the times for acylonitrile, but they are very probably more than a few minutes (and this is the true range of interest for the VM), so for the derivation of the probit coefficients for acrylonitrile we used the HCN dose-response data. (Acrylonitrile should, however, be significantly less of a hazard because its vapor pressure is lower.)

AMMONIA

The best estimate of dose-response and its time dependence is presented in the following table which is extracted from Table 6-4 (page 86) of reference [1] of this report.

% Deaths	Exposure Time (minutes)	Concentration (ppm)
3	45	1,750
	15	3,250
50	90	1,750
	45	3,250
97	90	3,250

*LC_{50} is the concentration that results in 50% deaths. Usually a time is specified when LC_{50} is given.

CARBON TETRACHLORIDE

The probits for carbon tetrachloride are derived from dose-response data presented below and extracted from pages 81 and 82 of Rausch et al. (1977).

% Deaths	Exposure Time (minutes)	Concentration (ppm)
5	5	6.67×10^3
	15	4.45×10^3
	30	3.18×10^3
	60	2.54×10^3
50	5	33.4×10^3
	15	22.25×10^3
	30	15.9×10^3
	60	12.7×10^3

CHLORINE

This is definitely not a Haber's Law toxicant. As concentration increases, the LCt_{50} decreases. Best estimates of time relationships are:

Time	LC_{50} (ppm)	LCt_{50} (ppm min)
Several hours	20	3,650
60 minutes	33	1,980
10 minutes		600

The dose-response would be more or less the same at the various exposure times. The best estimate of dose-response is:

% Lethality	Relative Dose
10	0.66
20	0.76
50	1.00
80	1.30
90	1.50

The basis for the injury probit coefficients is given on page 87 of Eisenberg et al. (1975).

HYDROGEN CHLORIDE

The probits for hydrogen chloride were derived from the dose-response data below extracted from Table 5-4 of Rausch et al. (1977).

% Fatalities	Exposure Time (minutes)	Concentration (ppm)
3	45	302
	15	906
	2.5	>1,342
50	90	302
	45	906
	10	>1,342
97	90	906

HYDROGEN CYANIDE

The following estimates of toxicity for man are from McNamara (1976), and may be confidently used as the best and most authoritative estimates available, and were used to derive the probit coefficients after conversion to ppm.*

Lethal Dosages for Man
in mg min m^{-3}

Exposure Time (minutes)	% Deaths 1	16	30	50	84	99
0.5	1,177	1,606	1,791	2,032	2,552	3,480
1	1,930	2,632	2,937	3,404	4,183	5,705
3	2,546	3,473	3,874	4,400	5,519	7,526
10	3,888	5,302	5,916	6,072	8,426	11,491
30	11,992	16,355	18,247	20,632	25,991	35,443

McNamara arrived at these estimates by the same sort of method that we have used previously. Data for various animals (Barcroft, 1931) were analyzed to get dose-response regression lines, and the susceptibility of man (i.e., absolute value of LCt_{50}) was assumed to be similar to that of the resistant goat or monkey. (This was supported by, inter alia, Barcroft's

*To convert mg min m^{-3} to ppm min, multiply by 0.906.

exposure of himself and a dog in the same chamber.) Data for the mouse were used to estimate relative LCt_{50} values for various times.

There is no basis for estimating incapacitating casualties, which are likely to be rare. A few might suffer serious brain damage or persistent mental impairment (there is some evidence that Barcroft was afflicted for about a year), but there is no quantitative information and they would certainly be a small minority at most. (Barcroft's self-exposure was probably between 825 mg min m^{-3} and 1,032 mg min m^{-3}.)

HYDROGEN FLUORIDE

Response to this toxicant obeys Haber's Law, i.e., effect is a function of dosage only and not a function of time and concentration. The dose-response data upon which the probit coefficients are based are presented in the following table as extracted from data on page 37 of Rausch, Tsao and Rowley (1977) (reference [3] of this report).

% Deaths	Dose (ppm min)
100	24,450
95	19,560
50	12,255
5	7,335

HYDROGEN SULFIDE

No data suitable for calculating dose-response regression for hydrogen sulfide (H_2S) has been found. However, it appears that the same dose-response as for hydrogen cyanide (HCN) is unlikely to be seriously in error. Evans (1967) stated:

> "There is a close similarity between the actions of HCN and H_2S on enzyme systems; both act as inhibitors of catalases and peroxidases (which all contain iron), and of dopa oxidase, succinic dehydrogenase, carbonic anhydrase, dipeptidases and benzamidase. HCN is known to combine with the iron in cytochrome A_3 (Keilin and Hartree, 1939): H_2S probably acts similarly, and has also been shown to inhibit, and at about the same molar concentrations, other systems connected with tissue oxidations, such as the $CoIH_2$ oxidase system (Slater, 1958)."

The most conspicuous effects of exposure to high concentrations are loss of consciousness and respiratory paralysis. Immediate first aid to restore respiration is effective. Victims who recover naturally or with medical aid seldom show any lasting harm unless hypoxia has damaged the

cerebral cortex. The gases are similar also in being quite rapidly detoxified in the body. For our purposes, this means that the simple dosage-response relation of Haber's Law does not apply. The gases differ in that H_2S has a stronger odor, particularly offensive at low concentrations (but at all concentrations, especially higher, olfactory fatigue is rapid), and it is also more irritant, so that its effect on the respiratory mucosa and eye dominates the picture at lower concentrations; eye effects may persist for some days.

The close similarity of the two toxicants, HCN and H_2S, suggests that the slope of the regression should be similar, and that the time-dependence of LCt should also be similar; the evidence is that detoxification occurs at a similar rate. We need therefore to check that lethal exposures are estimated to be of the same order.

Patty (1963) gives the "dangerous" exposure for 0.5 to 1 hour as 560 to 980 mg m^{-3}; i.e., a Ct of 34,650. RTECS (1977; apparently quoting Henderson and Haggard, but no reference is given) quotes an LCLo (least lethal concentration found) of 860 mg m^{-3} for 30 minutes (CT = 25,200). NIOSH (1977) gives a concentration of 1,400 mg m^{-3} as "rapidly" fatal, which may be supposed to mean of the order of 15 minutes (CT = 21,000). An estimate can be made from the well-known Poza Rica disaster (quoted in NIOSH, 1977), in which exposure for less than 20 minutes to an estimated 1,400 to 2,800 mg m^{-3} killed 22 and hospitalized an additional 307; residual nervous damage was reported in four. (The Ct, admittedly uncertain, may have been 2,100 x 15 = 31,500 mg min m^{-3}.) Deaths were delayed in a few: four at 2 hours, four at 6 hours, one at 24 hours, one each on the 2nd, 5th, 6th, and 9th days. "About half the domestic animals...died", mostly during the acute phase. NIOSH (1977) also quotes data for monkeys, including one unconscious and needing artificial respiration after 25 minutes at 700 mg m^{-3} (Ct = 34,300). Poda (1966) reported 123 cases of H_2S poisoning at an industrial plant. There were no fatalities but 25 became unconscious. Stay in hospital/infirmary was:

25: 1 hour
62: 1 to 4 hours
11: 4 to 12 hours
6: >12 hours.

The estimates of Ct for fatality, despite their unreliability, encourage the use of McNamara's HCN estimates for want of a better solution. Compare, for example, his LCt_{50} (30 minutes) of 20,632 mg min m^{-3} with the H_2S estimates. It appears that H_2S is a little less toxic; thus, probit coefficients were derived by doubling the HCN figures and converting them to ppm.

METHYL BROMIDE

All the evidence points to the fact that this is a strict Haber's Law toxicant over quite a wide range of concentrations. On the basis of dose-response data for several species including man, the best estimate for lethal dose in man is:

$LCt_{50} = 125 \times 10^3$ ppm min.

The slope of the dose-response relationship is based on the data developed in Rausch et al. (1977), page 89:

% Lethality	Concentration (ppm)
99	184.3×10^3
90	164.4×10^3
50	125.8×10^3
10	98.4×10^3
1	77.2×10^3

PHOSGENE

The probit coefficients for phosgene were derived from the following data extracted from Rausch et al., page 89:

% Lethality	Dose (ppm min)
95	1,052
50	765
15	526

PROPYLENE OXIDE

Propylene oxide is a liquid, with a boiling point of 34.2°C.

Epoxides of low molecular weight are primarily irritants with a mild depressant effect on the central nervous system. As alkylating agents, they have a radiomimetic effect.

Data in Patty show a considerable influence of time on effective concentration. An example from data on minimum intensity of exposure to

cause death in all animals:

Time (minutes)	Concentration (mg m^{-3})	Dosage (mg min m^{-3})
6	95,000	570,000
60	33,300	2,000,000
600	9,500	5,700,000

This time-dependence of dosage is not unlike HCN. These data were used to derive the exponent of the concentration.

The data also show that propylene oxide is not very toxic. With an LCt_{50} of the order of 1 x 10 mg min m^{-3}, it is similar to carbon tetrachloride and methyl bromide. The type of dose-dependence is however much more like that of CTC than MeBr (which has a Haber-type dependence on dosage). Despite the considerable differences in toxicology, we think that the CTC dose-response data should serve adequately for derivation of propylene oxide probit coefficients.

SULFUR DIOXIDE

This gas has been studied very extensively in chronic, low-level exposure, because of its prominence in air pollution monitoring and control. (It is, however, probably a proxy for sulfates that are the actual etiologic agents in epidemiological studies.) Low-level human exposure shows it to be highly irritant. Henderson and Haggard (1943), for example, give:

ppm	mg m^{-3}	
8-12	21-31	Threshold for throat irritation
10	26	Maximum allowable for long exposure
20	52	Threshold for immediate eye irrigation and coughing
50-100	130-260	Maximum for 1/2 to 1 hour
400-500	1040-1300	Dangerous for short exposure

Johnstone and Miller (1960) say that "intolerable irritation and laryngospasms" occur at 2,000 ppm (5,200 mg m^{-3}) and laryngeal edema follows. NIOSH (1974) says that in catastrophic exposure, asphyxiation is probable; if the victim survives, chemical bronchopneumonia may develop and may be fatal after some days. (A man exposed for 15 to 20 minutes died 17 days later.) Cynomolgus monkeys exposed to 200 to 1,000 ppm (520 to 2,600 mg m^{-3}) for one hour (Ct = 31,200 to 156,000 mg min m^{-3}) suffered permanent deterioration of respiratory function; they had been under chronic, low-level exposure for 30 weeks.

We have here a case unlike any previous one studied for the VM and unfortunately insufficient data to support reliable estimates. The strongly irritant properties are not unlike those of NH_3 or HCl, or even of Cl_2; and the persistent, possibly fatal pneumonia reminds one of Cl_2. But it is clearly not so dangerous as Cl_2 in doses below the asphyxiating level.

The best estimate for dose-response is that it is similar to HCl. Thus, the probits for sulfur dioxide were derived assuming dose-response is identical to HCl (in mg min m^{-3}).

TOLUENE

Toluene is a liquid; boiling point, 110.6°C; % in "saturated" air, 3.94. It is a powerful narcotic and a central nervous system depressant.

Some data from Patty and other sources are shown below:

Minimum for given effect in animal experiment (mice)

Prostration	10,000 - 12,000 mg m^{-3}
Death	30,000 - 45,000 mg m^{-3} [No times given.]

Rats: 18 days of 4-hour exposure

4,700 mg m^{-3}	No deaths	
15,000 mg m^{-3}	Deaths	[No numbers of deaths.]

Volunteers: at 8 hours unless stated

750 mg m^{-3}	Mild weakness, paresthesia
1,500 mg m^{-3}	Same, plus mental confusion
2,250 mg m^{-3}	Nausea, dizziness, staggering; mental confusion in 3 hours
3,000 mg m^{-3}	Incoordination at 3 hours

These show incapacitation at 2,250 × 8 × 60 - 1,080,000 mg min m^{-3} to 3,000 × 8 × 60 = 1,440,000 mg min m^{-3}.

Rats survived

37,600	20 min = 752,000 mg min m^{-3}
75,200	60 min - 4,512,000 mg min m^{-3}

Rats

18,750 × 150 min = 2,812,500 mg min m^{-3} were completely narcotized.
Daily exposure (time?) to 3,760 - 7,520 mg m^{-3} caused incapacitation.

These observations can be compared with those used for man in developing dose-response for carbon tetrachloride. Using the data from 10- to 30-minute exposures only, the earlier report shows:

Harassment (dizziness, etc.) at 39,000 to 150,000 mg min m^{-3};
Dangerous at 438,000 to 8,190,000 mg min m^{-3};
Lethal at 2,438,000 mg min m^{-3} and up.

These are in the same ballpark as the toluene data and the two chemicals are somewhat alike (as regards acute toxicity; not so alike for chronic exposure). We believe the CTC equation is adequate for toluene.

REFERENCES

Barcroft, J. (1931). The toxicity of atmospheres containing hydrocyanic acid gas. *J. Hyg. (Camb.) 31*:1-34.

Eisenberg, N.A., C.J. Lynch, and R.J. Breeding (1975). *Vulnerability Model: A Simulation System for Assessing Damage Resulting from Marine Spills*. Report No. CG-D-136-75 (NTIS AD-A015 245). Prepared by Enviro Control, Inc., for Department of Transportation, U.S. Coast Guard, June.

Evans, C.L. (1967). The toxicity of hydrogen sulphide and other sulphides. *Quart. J. Exp. Physiol. 52*:231-248.

Henderson, Y., and H.W. Haggard (1943). *Noxious Gases*. Reinhold Publishing Corp., New York, N.Y.

Johnstone, R.T., and S.E. Miller (1960). *Occupational Diseases and Industrial Medicine*. W.B. Saunders, Philadelphia, Pa.

Keilin, D., and E.F. Hartree (1939). Cytochrome and cytochrome oxidase. *Proc. Roy. Soc. (B) 127*:167-191.

McNamara, B.P. (1976). *Estimates of the Toxicity of Hydrocyanic Acid Vapors in Man*. Edgewood Arsenal EB-TR-76023, August.

NIOSH (1977). *Criteria for a Recommended Standard--Occupational Exposure to Hydrogen Sulfide*. NIOSH.

NIOSH (1974). *Criteria for a Recommended Standard--Occupational Exposure to Sulfur Dioxide*. NIOSH.

Patty, F.W. (1962). *Industrial Hygiene and Toxicology, Vol. II*. Interscience Publishers, New York, N.Y.

Poda, G.A. (1966). Hydrogen sulfide can be handled safely. *Arch. Environ. Health 12*:795-799.

Rausch, A.H., N.A. Eisenberg, and C.J. Lynch (1977). *Continuing Development of the Vulnerability Model: A Simulation System for Assessing Damage Resulting from Marine Spills*. Prepared by Enviro Control, Inc., for Department of Transportation, U.S. Coast Guard, February.

Rausch, A.H., C.K. Tsao, and R.M. Rowley (1977). *Third-Stage Development of the Vulnerability Model: A Simulation System for Assessing Damage Resulting from Marine Spills*. Prepared by Enviro Control, Inc., for Department of Transportation, U.S. Coast Guard, June.

RTECS: Registry of Toxic Effects of Chemical Substances (1977). NIOSH.

Slater, E.C. (1950). The components of the dihydroenzymase oxidase system. *Biochem. J. 48*:484-499.

Appendix D

DISPLAY PROCEDURE FILE, PROGRAMS AND JOBSTREAM

```
DISFTN.
IF(FILE(F,AS)=0)GET,F.
REWIND,F,LGO,LISTOUT.
RFL,60000.
FTN,I=F,L=LISTOUT,OPT=0,B=LGO.
1LODE,IF(FILE(LGO,AS)=0)GET,LGO.
ASCII.
REWIND,LISTOUT,LGO.
RETURN,NPFILE.
MAP(OFF)
ATTACH,DIS=DISSPLA/UN=LIBRARY.
ATTACH,UNIPLOT/UN=LIBRARY.
RFL,100000.
LDSET(LIB=DIS/UNIPLOT)
LGO.
REWIND,NPFILE.
IF(FILE(TEKANS,AS)=0)GET,TEKANS.
REWIND(TEKANS)
CALL(UNIPROC,S=2POST(DEVI=TEK,INPUT=TEKANS)
RETURN,TAPE62,LIST.
GOTO,2END.
EXIT.
DAYFILE.
GOTO,2END.
4014X,GOTO,1INFO.
4014R,GOTO,1INFO.
4010X,GOTO,1INFO.
4010R,GOTO,1INFO.
4002X,GOTO,1INFO.
4002R,GOTO,1INFO.
1CALX,GOTO,1INFO.
1CALR,GOTO,1INFO.
1INFO,GET,PLTINFO/UN=LIBRARY.
COPYCF,PLTINFO,OUTPUT,1,7,80.
2END,RETURN,PLTINFO,DIS.
```

FIGURE D-1. DISFTN

```
      PROGRAM FIRDISP(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,TAPE9)
       DIMENSION HEAD(2),TITL(7),TITL1(7),TITL2(7)
      DIMENSION XA(410),YA(410),AX(30,110),AY(30,110),AY1(30,110)
      DIMENSION BX(600),BY(600),BY1(600),CELLID(410)
      DIMENSION IPK(50),IPK1(50),IPK2(80),NP(20),PECNT(10)
      DIMENSION M(400),XAA(400),YAA(400),H(6,5),XAX(400),YAY(400)
      DIMENSION DX(410),DY(410),DY1(410),ZA(210),ZB(210),ZB1(210)
      DIMENSION LSTRNG(50),LST(50),LTV(80)
      DATA NP/0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0/
      DATA PECNT/1.0,25.0,50.0,75.0,99.0/
C     THIS PROGRAM IS FOR PLOTTING
C     NP=3 FOR PUFF MODEL,   NP=5 FOR PLUME MODEL
      WDIR=0.0
      PRINT 1020
 1020 FORMAT(*  WRITE THE PLOTTING FILE NAME*)
      READ(5,1000)AFILE
 1000 FORMAT(A8)
      PRINT 1094
 1094 FORMAT(*  ENTER THE PLOT TITLE (<21 CHARS.)--*)
      READ (5,1095) HEAD
 1095 FORMAT (2A10)
      PRINT 1021
 1021 FORMAT(*  DO YOU WANT TO CHANGE THE SPILL LOCATION+*)
      PRINT 1022
 1022 FORMAT(*  ANSWER 1 FOR YES, 0 FOR NO*)
      READ *, NA1
      IF(NA1 .EQ. 0)GO TO 1023
      PRINT 1024
 1024 FORMAT(*  WRITE THE CELL NUMBER WHERE THE SPILL WILL OCCUR.*)
      READ *, NCELL
 1023 PRINT 1025
 1025 FORMAT(*  DO YOU WANT TO CHANGE THE WIND DIRECTION FROM THE ONE*)
      PRINT 1026
 1026 FORMAT(*  WHICH YOU USED TO CALCULATE THE DATA+*)
      PRINT 1022
      READ *, NA2
      IF(NA2 .EQ. 0)GO TO 1030
      PRINT 1027
 1027 FORMAT(*  WRITE THE ANGLE BETWEEN X AXIS AND THE WIND DIRECTION*)
      PRINT 1028
 1028 FORMAT(*  IN DEGREE, + FOR COUNTERCLOCKWISE, - FOR CLOCKWISE*)
      READ *, WDIR
      WDIR=WDIR/57.2978
      WRITE(6,1029)NCELL,WDIR
 1029 FORMAT(5X,I4,5X,F6.2)
 1030 CONTINUE
      CALL PFSUB(6HATTACH,5HTAPE9,AFILE,0,0,0,0,UC,ES,EM)
      REWIND 9
      XORT=0.0
      YMAX=0.0
      YORT=0.0
    5 CONTINUE
      READ(9,1002)NPLOT,I1,I2,X,Y,Z
      IF(EOF(9))35,30
 1002 FORMAT(3I3,2E12.4,A10)
   30 IF(NPLOT .EQ. 200)GO TO 10
      IF(NPLOT .EQ. 1)GO TO 15
      IF(NPLOT .EQ. 3)GO TO 20
      IF(NPLOT .EQ. 5)GO TO 25
      IF(NPLOT .EQ. 6 .OR. NPLOT .EQ. 7)GO TO 76
       IF(NPLOT. EQ. 199) THU=X/1000.
      IF(NPLOT .EQ. 8 .OR. NPLOT .EQ. 9)GO TO 76
      GO TO 5
```

FIGURE D-2. FIRDISP

```
C     READ TOXICITY,FLAMMABILITY,WIND SPEED,CONCENTRATION
   10 ITOX=I1
      UWIND=X/100.0
      IFLM=I2
      CONCEN=Y
      GO TO 5
C     READ CELL CENTER
   15 I=I1
      NI1=I
      XA(I)=X*1000.0
      YA(I)=Y*1000.0
      CELLID(I)=Z
      NP(NPLOT)=NPLOT
      GO TO 5
C     READ PUFF MODEL DATA
   20 I=I1
      J=I2
      AX(I,J)=X*1000.0
      AY(I,J)=Y*1000.0
      AY1(I,J)=-Y*1000.0
      NI2=I
      NP(NPLOT)=NPLOT
      IF(AY(I,J) .GT. YMAX)YMAX=AY(I,J)
      GO TO 5
C     READ PLUME MODEL DATA
   25 I=I1
      BX(I)=X*1000.0
      BY(I)=Y*1000.0
      BY1(I)=-Y*1000.0
      NI4=I
      NP(NPLOT)=NPLOT
      IF(BX(I) .GT. XMAX)XMAX=BX(I)
      IF(BY(I) .GT. YMAX)YMAX=BY(I)
      GO TO 5
   76 NP(NPLOT)=NPLOT
      IF(NPLOT .EQ. 6 .OR. NPLOT .EQ. 7)I=NPLOT-5
      IF(NPLOT .EQ. 8 .OR. NPLOT .EQ. 9)I=NPLOT-7
      J=I1
      IGNIO=I2
      R(I,J)=X*305.0
      IF(R(I,J) .GT. YGRT)YGRT=R(I,J)
      GO TO 5
   35 CONTINUE
      IF(NCELL .EQ. 0)GO TO 517
      XCEN=XA(NCELL)
      YCEN=YA(NCELL)
  517 CONTINUE
      IF(NCELL .EQ. 0 .AND. WDIR .EQ. 0.0)GO TO 511
      DO 513 I=1,NI1
      IF(NCELL .EQ. 0)GO TO 515
      XA(I)=XA(I)-XCEN
      YA(I)=YA(I)-YCEN
      IF(WDIR .EQ. 0.0)GO TO 513
  515 XA(I)=XA(I)*COS(WDIR)+YA(I)*SIN(WDIR)
      YA(I)=-XA(I)*SIN(WDIR)+YA(I)*COS(WDIR)
  513 CONTINUE
  511 CONTINUE
      REWIND 9
      IF(NP(3) .EQ. 3)XMAX=AX(NI2,100)
      J=1
      DO 92 I=1,NI1
      IF(XA(I) .LT. 0.0)GO TU 92
      IF(ABS(YA(I)) .GT. YMAX)GO TO 92
       IF (ABS(XA(I)).LT.0.0.OR.ABS(XA(I)).GT.XMAX) GOTO 92
```

FIGURE D-2 (continued)

```
      M(J)=I
      XAA(J)=XA(I)
      YAA(J)=YA(I)
      NJ=J
      J=J+1
   92 CONTINUE
      IF(XMAX .LT.  99.0)GO TO 302
      IF(XMAX .LT. 1000.0)GO TO 303
      IF(XMAX .LT. 10000.0)GO TO 304
       PRINT 3301
 3301  FORMAT(* WARNING--MAXIMUM DOWNWIND DISTANCE EXCEECS 10 KM.*)
       GOTO 304
  302 XMAX=XMAX+5.0
      XLIM=AINT(XMAX)
      XINC=XLIM/4.0
      GO TO 212
  303 XMAX=XMAX+50.0
      XLIM=XMAX-AMOD(XMAX,5.0)
      XINC=XLIM/4.0
      GO TO 212
  304 XMAX=XMAX+500.0
      XLIM=XMAX-AMOD(XMAX,50.0)
      XINC=XLIM/4.0
  212 IF(YMAX .LT. 10.0)GO TO 313
      IF(YMAX .LT. 100.0)GO TO 314
      IF(YMAX .LT. 1000.0)GO TO 315
  313 YMAX=YMAX+0.5
      YLIM=YMAX-AMOD(YMAX,0.5)
      YINC=YLIM/2.0
      GO TO 214
  314 YMAX=YMAX+5.0
      YLIM=AINT(YMAX)
      YINC=YLIM/2.0
      GO TO 214
  315 YMAX=YMAX+50.0
      YLIM=YMAX-AMOD(YMAX,5.0)
      YINC=YLIM/2.0
  214 XSCAL=XLIM/12.0
      YSCAL=YLIM/4.0
      YMIN=-YLIM
      WRITE(6,1079)XLIM,YLIM,YMIN,XINC,YINC
 1079 FORMAT(5X,5F8.2)
      CALL UNIPLOT
      CALL PAGE(11.0,14.0)
      ENCODE(51,1096,TITL) NLAC
 1096 FORMAT (29HLOWER FLAMMABLE LIMIT CURVE  ,2A10,1H5)
      IF(NP(3) .EQ. 0 .AND. NP(5) .EQ. 0)GO TO 71
      CALL TITLE(TITL,-100,13HX DISTANCE(M),
     113,13HY DISTANCE(M),13,12.0,8.0)
C     PLOT LOWER LIMIT FLAMMABLE CONCENTRATION
   46 CALL GRAF(0.,XINC,XLIM,YMIN,YINC,YLIM)
      CALL MARKER(1)
      CALL BLNK1(3.4,8.5,7.3,8.3,1)
      CALL CURVE(XAA,YAA,NJ,-1)
      IF(NJ .EQ. 0)GO TO 70
      J=1
   56 CONTINUE
      XX=XAA(J)-0.1
      YY=YAA(J)
      XTES=XAA(J)-XAA(J-1)
      YTES=YAA(J)-YAA(J-1)
      IF (XTES .EQ. 0. .AND. YTES .EQ. 0.) M(J)=M(J-1)
      ENCODE(20,58,U)M(J)
```

FIGURE D-2 (continued)

```
 58 FORMAT(1H ,I3,1HS)
    CALL RLMESS(U,100,XX,YY)
    IF(J .EQ.NJ)GO TO 70
    IF(J .GT. 400)GO TO 70
    J=J+1
    GO TO 56
 70 CONTINUE
    IF(NP(4) .EQ. 4)GO TO 48
    NJMP=1
    IF (UWIND. LE. 5.0) NJMP=2
    DO 50 I=2,NI2,NJMP
     J2=0
    DO 52 J=1,101
     IF (AX(I,J).LT.0.) GO TO 52
     J2=J2+1
    DX(J2)=AX(I,J)
     DY(J2)=AY(I,J)
    DY1(J2)=-DY(J2)
 52 CONTINUE
    CALL CURVE(DX,DY,J2,0)
    CALL CURVE(DX,DY1,J2,0)
    KI=5*(I-1)
    ENCODE(40,26,LSTRNG)KI
 26 FORMAT(I3,6H SECS$)
    CALL LINES(LSTRNG,IPK,1)
    XPOS=AX(I,51)/XSCAL
    IF (I.EQ.5.OR.I.EQ.10.OR.I.EQ.15.OR.I.EQ.20) YPOSII=0.
    YPOS=4.0-ABS(AY(I,51))/YSCAL+YPOSII
     YPOSII=YPOSII+.3
    CALL STORY(IPK,1,XPOS,YPOS)
    IF(I .EQ. NI2)GO TO 54
    IF(I .GT. 25)GO TO 54
 50 CONTINUE
 48 CALL CURVE(BX,BY,NI4,0)
    CALL CURVE(BX,BY1,NI4,0)
 54 ENCODE(40,60,LST)UWIND
    CALL RESET(5HBLNKS)
 60 FORMAT(9HWIND VEL ,F5.2,5H M/S$)
    CALL LINES(LST,IPK1,1)
    CALL STORY(IPK1,1,4.0,8.0)
     CONKM3=CONCEN*1000.
    ENCODE(80,64,LTV)CONKM3
 64 FORMAT(18HFLAMMABLE LIMIT ,E9.4,7H KG/CM$)
    CALL LINES(LTV,IPK2,1)
    CALL STORY(IPK2,1,4.0,7.6)
    CALL ENDPL(-1)
 71 CONTINUE
C     THE FOLLOWING IS FOR PLOTTING FIRE DAMAGE
 78 CONTINUE
    ENCODE(50,1097,TITL1) HEAD
1097 FORMAT(18HFIRE LETHALITY  ,2A10,1H$)
    ENCODE(50,1098,TITL2) HEAD
1098 FORMAT(13HFIRE INJURY  ,2A10,1H$)
    IF(YGRT .LT. 100.0)GO TO 343
    IF(YGRT .LT. 1000.0)GO TO 344
    IF(YGRT .LT. 10000.0)GO TO 345
343 YGRT=YGRT+5.0
    YTOP=AINT(YGRT)
    GO TO 241
344 YGRT=YGRT+50.0
    YTOP=YGRT-AMOD(YGRT,5.0)
    GO TO 241
```

FIGURE D-2 (continued)

```
345 YGRT=YGRT+500.0
    YTOP=YGRT-AMOD(YGRT,50.0)
241 CONTINUE
 75 XC = XA(IGNID)
    YC = YA(IGNID)
 83 DO 84 I=1,2
    IF(I.EQ.1)CALL TITLE(TITL1,-100,13HX DISTANCE(M),
   113,13HY DISTANCE(M),13,12.0,8.0)
    IF(I.EQ.2)CALL TITLE(TITL2,-100,13HX DISTANCE(M),
   113,13HY DISTANCE(M),13,12.0,8.0)
    IF(I .EQ. 1)GO TO 371
    IF(I .EQ. 2)GO TO 372
371 YMAX=AINT(0.90*YTOP)
    GO TO 373
372 YMAX=YTOP
373 CONTINUE
    CALL BLNK2(3.8,7.7,7.3,8.3,1)
    YINC=YMAX/2.0
    XMAX=4.0*YMAX/3.0
    XINC=XMAX/2.0
    YMIN=-YMAX
    XMIN=-XMAX
    YSCAL=YMAX/4.0
    XSCAL=XMAX/6.0
    J=1
    DO 215 K=1,NI1
    XAX(K)=XA(K)-XC
    YAY(K)=YA(K)-YC
    IF(ABS(XAX(K)) .GT. XMAX)GO TO 215
    IF(ABS(YAY(K)) .GT. YMAX)GO TO 215
    XAA(J)=XAX(K)
    YAA(J)=YAY(K)
    M(J)=K
    NJ1=J
    J=J+1
215 CONTINUE
    CALL GRAF(XMIN,XINC,XMAX,YMIN,YINC,YMAX)
    CALL MARKER(1)
    CALL CURVE(XAA,YAA,NJ1,-1)
    L=1
116 CONTINUE
    XX=XAA(L)-0.1
    YY=YAA(L)
    XTES=XAA(L)-XAA(L-1)
    YTES=YAA(L)-YAA(L-1)
    IF (XTES.EQ.0. .OR.YTES.EQ.0.) M(L)=M(L-1)
    ENCODE(29,120,U)M(L)
120 FORMAT(1H ,I3,1H$)
    CALL RLMESS(U,100,XX,YY)
    IF(L .EQ. NJ1)GO TO 127
    L=L+1
    IF( L .EQ. 400)GO TO 127
    GO TO 116
```

FIGURE D-2 (continued)

```
  127 CONTINUE
      XPOS=4.0
      DO 100 J=1,5
      DIST=2.0*R(I,J)/200.0
      ZA(1) = -R(I,J)
      ZB(1)=0.
      ZB1(1)=0.
      ZB(201)=0.
      ZB1(201)=0.
      DO 110 K=2,201
      ZA(K)=ZA(K-1)+DIST
      IF(ZA(K) .GT. R(I,J))GO TO 112
      ZB(K)=SQRT(R(I,J)**2 - ZA(K)**2)
      ZB1(K) = -ZB(K)
  110 CONTINUE
  112 CALL CURVE(ZA,ZB,201,0)
      CALL CURVE(ZA,ZB1,201,0)
      XPOS=.5+XPOS
      YPOS=4.0 - ZB(100)/YSCAL
      ENCODE(30,114,LSB)PECNT(J)
  114 FORMAT(F5.1,3H % ,1H$)
       CALL SCMPLX
      CALL LINES(LSB,IPK,1)
      CALL STORY(IPK,1,XPOS,YPOS)
  100 CONTINUE
      CALL RESET(5HBLANKS)
      ENCODE(30,60,LST)UWIND
       CALL SIMPLX
      CALL LINES(LST,IPK1,1)
      CALL STORY(IPK1,1,4.0,8.0)
      ENCODE(50,176,LTV)TMG
  176 FORMAT(13HVAPOR MASS =  ,E8.3,4H KGS)
      CALL LINES(LTV,IPK2,1)
      CALL STORY(IPK2,1,4.0,7.6)
      IF(I .EQ. 1) CALL ENDPL(-2)
      IF(I .EQ. 2) CALL ENDPL(-3)
   84 CONTINUE
 3000 CONTINUE
      CALL DONEPL
      END
```

FIGURE D-2 (concluded)

```
      PROGRAM EXPDISP(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,TAPE9)
      DIMENSION HEAD(2),TITL(7),TITL1(7),TITL2(7)
      DIMENSION XA(405),YA(405),CELLID(405),ZA(210),ZB(210),ZB1(210)
      DIMENSION NP(20),PECNT(10),YM(6)
      DIMENSION IPK(50),IPK1(50),IKP2(80),XAX(400),YAY(400)
      DIMENSION LSTRNG(50),LSB(50),LTV(80)
      DIMENSION M(400),XAA(400),YAA(400),R(6,5)
      DATA NP/0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0/
      DATA PECNT/1.0,25.0,50.0,75.0,99.0/
      DATA YM/0.0,0.0,0.0,0.0,0.0,0.0/
C     THIS PROGRAM IS FOR PLOTTING
C     NP=200 FOR GENERAL DATA,  =1 FOR CELL CENTER
      PRINT 1020
 1020 FORMAT(*  WRITE THE PLOTTING FILE NAME*)
      READ(5,1000)AFILE
 1000 FORMAT(A8)
      PRINT 1094
 1094 FORMAT(*  ENTER THE PLOT TITLE (<21 CHARS.)--*)
      READ (5,1095) HEAD
 1095 FORMAT(2A10)
      PRINT 1021
 1021 FORMAT(*  DO YOU WANT TO CHANGE THE EXPLOSION LOCATION, *)
      PRINT 1022
 1022 FORMAT(*  ANSWER 1 FOR YES, 0 FOR NO*)
      READ *, NAN1
      IF(NAN1 .EQ. 0)GO TO 1024
      PRINT 1023
 1023 FORMAT(*  WRITE THE CELL NUMBER WHERE EXPLOSION WILL OCCUR*)
      READ *, NCELL
 1024 CONTINUE
      CALL PFSUB(6HATTACH,5HTAPE9,AFILE,0,0,0,0,UC,ES,EM)
      YMAX=1.0
      READ(9,1001)N,ITOX,IFLM,UWIND,CONCEN,TMG
 1001 FORMAT(3I3,3E12.5)
      TMG=TMG/1000.0
      UWIND=UWIND/100.0
    5 CONTINUE
      READ(9,1002)NPLOT,I1,I2,X,Y,Z
      IF(EOF(9))45,30
 1002 FORMAT(3I3,2E12.5,A10)
   30 IF(NPLOT .EQ. 200)GO TO 10
      IF(NPLOT .EQ. 1)GO TO 15
      IF(NPLOT .EQ. 14)GO TO 20
      IF(NPLOT .EQ. 15)GO TO 25
      IF(NPLOT .EQ. 16)GO TO 28
      IF(NPLOT .EQ. 17)GO TO 31
      IF(NPLOT .EQ. 18)GO TO 35
      IF(NPLOT .EQ. 19)GO TO 38
        IF (NPLOT. EQ. 199) TMG=Y*.001
      GO TO 5
C     READ TOXCITY,FLAMMABILITY,WIND SPEED, CONCENTRATION
   10 ITOX=I1
      IFLM=I2
      CONCEN=Y
      GO TO 5
C     READ CELLS
   15 I=I1
      NI1=I
      XA(I)=X*1000.0
      YA(I)=Y*1000.0
      CELLID(I)=Z
      NP(NPLOT)=NPLOT
      GO TO 5
```

FIGURE D-3. EXPDISP

```
C     NPLOT=14 FOR IMPACT DEATH
   20 I=NPLOT - 13
      J=I1
      IGNID=I2
      R(I,J)=X*1000.0
      NP(NPLOT)=NPLOT
      IF(R(I,J) .GT. YM(I))YM(I)=R(I,J)
      GO TO 5
C     NPLOT =15 FOR IMPACT INJURY
   25 I=NPLOT-13
      J=I1
      IGNID=I2
      R(I,J)=X*1000.0
      IF(R(I,J) .GT. YM(I))YM(I)=R(I,J)
      NP(NPLOT)=NPLOT
      GO TO 5
C     NPLOT=16 FOR FLYING SEGAMENT INJURY
   28 NP(NPLOT)=NPLOT
      I=NPLOT-13
      J=I1
      IGNID=I2
      R(I,J)=X*1000.0
      IF(R(I,J) .GT. YM(I))YM(I)=R(I,J)
      GO TO 5
C     NPLOT=17  FOR PEAK OVERPRESSURE DEATH
   31 NP(NPLOT)=NPLOT
      I=NPLOT-13
      J=I1
      IGNID=I2
      R(I,J)=X*1000.0
      IF(R(I,J) .GT. YM(I))YM(I)=R(I,J)
      GO TO 5
C     NPLOT=18 FOR PEAK OVERPRESSURE INJURY
   35 NP(NPLOT)=NPLOT
      I=NPLOT-13
      J=I1
      IGNID=I2
      R(I,J)=X*1000.0
      IF(R(I,J) .GT. YM(I))YM(I)=R(I,J)
      GO TO 5
C     NPLOT=19 FOR STRUCTURE DAMAGE
   38 NP(NPLOT)=NPLOT
      I=NPLOT-13
      J=I1
      IGNID=I2
      R(I,J)=X*1000.0
      IF(R(I,J) .GT. YM(I))YM(I)=R(I,J)
      GO TO 5
   45 CONTINUE
      YMAX=AMAX1(YM(1),YM(2),YM(3),YM(4),YM(5),YM(6))
      YORT=YMAX
      REWIND 9
      IF(YMAX .LT. 100.0)GO TO 332
      IF(YMAX .LT. 1000.0)GO TO 333
      IF(YMAX .LT. 10000.0)GO TO 334
  332 YMAX=YMAX+5.0
      YMAX=AINT(YMAX)
      GO TO 241
  333 YMAX=YMAX+50.0
      YMAX=YMAX-AMOD(YMAX,5.0)
      GO TO 241
```

FIGURE D-3 (continued)

```
 334 YMAX=YMAX+500.0
     YMAX=YMAX-AMOD(YMAX,50.0)
 241 CONTINUE
     IF(NAN1 .EQ. 0)GO TO 731
     XC=XA(NCELL)
     YC=YA(NCELL)
     GO TO 732
 731 CONTINUE
     XC=XA(IGNID)
     YC=YA(IGNID)
 732 CONTINUE
  83 CONTINUE
     CALL UNIPLOT
      CALL PAGE(11.0,14.0)
      ENCODE(50,1096,TITL) HEAD
1096 FORMAT(25HDEATH FROM OVERPRESSURE  ,2A10,1H$)
     ENCODE(50,1097,TITL1)HEAD
1097 FORMAT(26HINJURY FROM OVERPRESSURE  ,2A10,1H$)
     ENCODE(50,1098,TITL2)HEAD
1098 FORMAT(18HSTRUCTURE DAMAGE  ,2A10,1H$)
     DO 50 I=4,6
     IF(I.EQ.1)CALL TITLE(18HDEATH FROM IMPACTS,-100,13HX DISTANCE(M),
    113,13HY DISTANCE(M),13,12.0,8.0)
     IF(I.EQ.2)CALL TITLE(19HINJURY FROM IMPACTS,-100,13HX DISTANCE(M),
    113,13HY DISTANCE(M),13,12.0,8.0)
     IF(I.EQ.3)CALL TITLE(29HINJURY FROM FLYING FRAGEMENTS,-100,
    113HX DISTANCE(M),13,13HY DISTANCE(M),13,12.0,8.0)
     IF(I.EQ.4)CALL TITLE(TITL,-100,
    113HX DISTANCE(M),13,13HY DISTANCE(M),13,12.0,8.0)
     IF(I.EQ.5)CALL TITLE(TITL1,-100,
    113HX DISTANCE(M),13,13HY DISTANCE(M),13,12.0,8.0)
     IF(I.EQ.6)CALL TITLE(TITL2,-100,13HX DISTANCE(M),
    113,13HY DISTANCE(M),13,12.0,8.0)
     RAT=(YM(I)/YMAX) + 0.1
     IF(RAT .GT. 1.0)RAT=1.0
     RAT=AINT(10.0*RAT)/10.0
     CALL BLNK1(3.4,8.9,7.8,8.3,0)
     YTOP=YMAX*RAT
     YINC=YTOP/2.0
     XMAX=4.0*YTOP/3.0
     XINC=XMAX/2.0
     YMIN=-YTOP
     XMIN=-XMAX
     XSCAL=XMAX/6.0
     YSCAL=YTOP/4.0
     NJ=0
     J=1
     DO 216 K=1,NI1
     XAX(K)=XA(K)-XC
     YAY(K)=YA(K)-YC
     IF(ABS(XAX(K)).GT. XMAX)GO TO 216
     IF(ABS(YAY(K)) .GT. YTOP)GO TO 216
     XAA(J)=XAX(K)
     YAA(J)=YAY(K)
     M(J)=K
     NJ=J
     J=J+1
 216 CONTINUE
     CALL GRAF(XMIN,XINC,XMAX,YMIN,YINC,YTOP)
     CALL MARKER(1)
     CALL CURVE(XAA,YAA,NJ,-1)
     IF(NJ .EQ. 0)GO TO 127
     L=1
```

FIGURE D-3 (continued)

```
116 CONTINUE
    XX=XAA(L)-0.1
    YY=YAA(L)
    XTES=XAA(L)-XAA(L-1)
    YTES=YAA(L)-YAA(L-1)
    IF (XTES.EQ.0. .AND. YTES.EQ.0.) M(L)=M(L-1)
    ENCODE(20,120,U)M(L)
120 FORMAT(1H ,I3,1H$)
    CALL RLMESS(U,100,XX,YY)
    IF(L .EQ. NJ)GO TO 127
    L=L+1
    IF(L .GT. 400)GO TO 127
    GO TO 116
127 CONTINUE
    XPOS=3.8
    DO 100 J=1,5
    DX=2.0*R(I,J)/200.0
    ZA(1)=-R(I,J)
    ZB(1)=0.
    ZB1(1)=0.
    ZB(201)=0.
    ZB1(201)=0.
    DO 110 K=2,201
    ZA(K)=ZA(K-1)+DX
    IF(ZA(K) .GT. R(I,J))GO TO 112
    ZB(K)=SQRT(R(I,J)**2-ZA(K)**2)
    ZB1(K)=-ZB(K)
110 CONTINUE
112 CALL CURVE(ZA,ZB,201,0)
    CALL CURVE(ZA,ZB1,201,0)
    XPOS=.5+XPOS
    CALL SCMPLX
    YPOS=4.0-ZB(100)/YSCAL
    ENCODE(30,114,LSB)PECNT(J)
114 FORMAT(F5.1,3H % ,3H $*)
    CALL LINES(LSB,IPK,1)
    CALL STORY(IPK,1,XPOS,YPOS)
100 CONTINUE
    CALL SIMPLX
    CALL RESET(5HBLNK1)
    ENCODE(80,55,LTV)TMG
 55 FORMAT(16HMASS EXPLODED = ,E9.3,4H KG$)
    CALL LINES(LTV,IPK2,1)
    CALL STORY(IPK2,1,4.0,6.0)
    IF(I .EQ. 1) CALL ENDPL(-1)
    IF(I .EQ. 2) CALL ENDPL(-2)
    IF(I .EQ. 3)CALL ENDPL(-3)
    IF(I .EQ. 4)CALL ENDPL(-4)
    IF(I .EQ. 5)CALL ENDPL(-5)
    IF(I .EQ. 6)CALL ENDPL(-6)
 50 CONTINUE
3000 CONTINUE
    CALL DONEPL
    END
```

FIGURE D-3 (concluded)

```
      PROGRAM TOXDISP(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,TAPE9)
      DIMENSION XA(410),YA(410),AX(30,103),AY(30,103),AY1(30,103)
      DIMENSION HEAD(2),TITL(7),TITL1(7),TITL2(7)
      DIMENSION BX(601),BY(601),BY1(601),CELLID(410)
      DIMENSION NP(20),M(400),NK(2,20),R(3,10),PECNT(10)
      DIMENSION XAA(400),YAA(400),DX(110),DY(119),DY1(110)
      DIMENSION CX(2,5,300),CY(2,5,300),CY1(2,5,300)
      DIMENSION XC(400),YC(400),YC1(400),XGR(3),YGR(3)
      DIMENSION LSTRNG(50),LST(50),LTV(60)
      DIMENSION IPK(50),IPK1(50),IPK2(60)
      DATA NP/0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0/
      DATA NI1/400/,NI2/15/,NI4/400/
      DATA NJ/0/,NJ1/0/
      DATA IDRAW/0/
      DATA PECNT/1.0,0.25,0.50,0.75,0.99,0/
C     THIS PROGRAM IS FOR PLOTTING TOXIC CASUALTY
      WRITE(6,1003)
 1003 FORMAT(*  WRITE THE PLOTTING DATA FILE NAME*)
C     NP=200 FOR GENERAL DATA,  =1 FOR CELL CENTER
C     NP=2 FOR PUFF TOXIC, =4 FOR PLUME TOXIC
      READ(5,1000)AFILE
 1000 FORMAT(A8)
      PRINT 1094
 1094 FORMAT(* ENTER THE PLOT TITLE (<21 CHARS.)--*)
      READ (5,1095) HEAD
 1095 FORMAT(2A10)
      WRITE(6,1004)
 1004 FORMAT(*  DO YOU WANT TO CHANGE THE SPILL LOCATION,*)
       WRITE(6,1005)
 1005 FORMAT(*  ANSWER 1 FOR YES, 0 FOR NO*)
      READ *, NANS1
      IF(NANS1 .EQ. 0)GO TO 802
      WRITE(6,1007)
 1007 FORMAT(*  WRITE THE CELL NUMBER WHERE THE SPILL WILL OCCUR*)
      READ *, NCELL
  802 WRITE(6,1008)
 1008 FORMAT(*  DO YOU WANT TO CHANGE THE WIND DIRECTION FROM THE ONE*)
      PRINT 1015
 1015 FORMAT(*  WHICH YOU USED TO CALCULATE THE PLOTTING DATA,*)
      WRITE(6,1005)
      READ *, NANS2
      IF(NANS2 .EQ. 0)GO TO 803
      WRITE(6,1011)
 1011 FORMAT(*  WRITE THE ANGLE BETWEEN X-AXIS AND WIND DIRECTION*)
      WRITE(6,1012)
 1012 FORMAT(*  IN DEGREE, COUNTERCLOCKWISE IS +, CLOCKWISE IS -*)
      READ *, WDIR
      WDIR=WDIR/57.2978
  803 CONTINUE
      CALL PFSUB(6HATTACH,5HTAPE9,AFILE,0,0,0,0,UC,ES,EM)
      REWIND 9
      I=1
      XORT=0.0
      YORT=.00005
      YMAX=.00005
      READ(9,1001)N,ITOX,IFLM,UWIND,CONCEN,TMG
 1001 FORMAT(3I3,3E12.4)
      CONCEN=CONCEN/1000.0
      TMG=TMG/1000.0
      UWIND=UWIND/100.0
      WRITE(6,1001)N,ITOX,IFLM,UWIND,CONCEN,TMG
    5 CONTINUE
      READ(9,1002)NPLOT,I1,I2,X,Y,Z
      IF(EOF(9))35,30
```

FIGURE D-4. TOXDISP

```
1002 FORMAT(3I3,2E12.4,A10)
  30 IF(NPLOT .EQ. 200)GO TO 10
     IF(NPLOT .EQ. 1)GO TO 15
     IF(NPLOT .EQ. 2)GO TO 20
     IF(NPLOT .EQ. 4)GO TO 25
     IF(NPLOT .EQ. 10 .OR. NPLOT .EQ. 11)GO TO 125
     IF(NPLOT .EQ. 12 .OR. NPLOT .EQ. 13)GO TO 126
     IF (NPLOT .EQ. 199) THG=X/1000.
     GO TO 5
C    READ TOXICITY,FLAMMABILITY,WIND SPEED AND CONCENTRATION
  10 ITOX=I1
     IFLM=I2
     UWIND=X/100.0
     CONCEN=Y
     GO TO 5
C    READ CELL
  15 I=I1
     NI1=I
     XA(I)=X
     YA(I)=Y
     CELLID(I)=Z
     NP(NPLOT)=NPLOT
     GO TO 5
C    READ PUFF DATA
  20 I=I1
     J=I2
     AX(I,J)=X
     AY(I,J)=Y
     AY1(I,J)=-Y
     NI2=I
     NP(NPLOT)=NPLOT
     IF(Y .GT. YMAX)YMAX=Y
     GO TO 5
C    READ PLUME DATA
  25 I=I1
     BX(I)=X
     BY(I)=Y
     BY1(I)=-Y
     NI4=I
     NP(NPLOT)=NPLOT
     IF(Y .GT. YMAX)YMAX=Y
     GO TO 5
C    READ PLUME DATA
 125 NP(NPLOT)=NPLOT
     I=NPLOT-9
     J=I1
     K=I2
     NK(I,J)=K
     CX(I,J,K)=X
     CY(I,J,K)=Y
     IF(Y .GT. YGRT)YGR(I)=Y
     IF(X .GT. XGRT)XGR(I)=X
     YGRT=YGR(I)
     XGRT=XGR(I)
     IDRAW=1
     GO TO 5
 126 NP(NPLOT)=NPLOT
     I=NPLOT-11
     J=I1
     K=I2
     NK(I,J)=K
     CX(I,J,K)=X
     CY(I,J,K)=Y
     IF(Y .GT. YGRT)YGR(I)=Y
     IF(X .GT. XGRT)XGR(I)=X
     YGRT=YGR(I)
     XGRT=XGR(I)
     IDRAW=1
     GO TO 5
```

FIGURE D-4 (continued)

```
   35 CONTINUE
      IF(NCELL .EQ. 0)GO TO 517
      XCEN=XA(NCELL)
      YCEN=YA(NCELL)
  517 CONTINUE
      IF(NCELL .EQ. 0 .AND. WDIR .EQ. 0.0)GO TO 511
      DO 513 I=1,NI1
      IF(NCELL .EQ. 0)GO TO 515
      XA(I)=XA(I)-XCEN
      YA(I)=YA(I)-YCEN
  515 XA(I)=XA(I)*COS(WDIR) + YA(I)*SIN(WDIR)
      YA(I)=-XA(I)*SIN(WDIR) + YA(I)*COS(WDIR)
  513 CONTINUE
  511 CONTINUE
      WRITE(6,1089)NI1,NI2,NI4,NK(1)
 1089 FORMAT(5X,*NCELLS=*,I4,* NPUFF CVS=*,I4,* NPLU CVS=*,I4,* NK=*,I4)
      REWIND 9
      NK=NK(1)
      IF(NP(2) .EQ. 2)XMAX=AX(NI2,100)
      IF(NP(4) .EQ. 4)XMAX=BX(NI4)
      J=1
      DO 92 I=1,NI1
      IF(XA(I) .LT. 0.0)GO TO 92
      IF(NP(2) .EQ. 2 .AND. ABS(YA(I)) .GT. YMAX)GO TO 92
      IF(NP(4) .EQ. 4 .AND. ABS(YA(I)) .GT. YMAX)GO TO 92
      IF((NP(2).EQ.2.OR.NP(4).EQ.4).AND.XA(I).GT.XMAX) GO TO 92
      M(J)=I
      XAA(J)=XA(I)
      YAA(J)=YA(I)
      NJ=J
      J=J+1
   92 CONTINUE
      IF(XMAX .LT. 1.0)GO TO 302
      IF(XMAX .LT. 10.0)GO TO 303
      IF(XMAX .LT. 100.0)GO TO 304
      IF(XMAX .LT. 1000.0)GO TO 305
  302 XMAX=XMAX+0.05
      XLIM=XMAX-AMOD(XMAX,0.05)
      XINC=XLIM/4.0
      GO TO 212
  303 XMAX=XMAX+0.5
      XLIM=XMAX-AMOD(XMAX,0.5)
      XINC=XLIM/4.0
      GO TO 212
  304 XMAX=XMAX+5.0
      XLIM=AINT(XMAX)
      XINC=XLIM/4.0
      GO TO 212
  305 XMAX=XMAX+50.0
      XLIM=XMAX-AMOD(XMAX,5.0)
      XINC=XLIM/4.0
  212 IF(YMAX .LT. 0.1)GO TO 312
      IF(YMAX .LT. 1.0)GO TO 313
      IF(YMAX .LT. 10.0)GO TO 314
  312 YMAX=YMAX+0.005
      YLIM=YMAX-AMOD(YMAX,0.005)
      YINC=YLIM/2.0
      GO TO 214
  313 YMAX=YMAX+0.05
      YLIM=YMAX-AMOD(YMAX,0.05)
      YINC=YLIM/2.0
      GO TO 214
```

FIGURE D-4 (continued)

```
  314 YMAX=YMAX+0.5
      YLIM=YMAX-AMOD(YMAX,0.5)
      YINC=YLIM/2.0
  214 XSCAL=XLIM/12.0
      YSCAL=YLIM/4.0
      YMIN=-YLIM
      WRITE(6,1079)XLIM,YLIM,YMIN,XINC,YINC
 1079 FORMAT(5X,5F8.2)
      CALL UNIPLOT
      CALL PAGE(11.0,14.0)
      ENCODE(50,1096,TITL) HEAD
 1096 FORMAT(24HTOXIC IRRITATION CURVE  ,2A10,1H$)
      ENCODE(50,1097,TITL1) HEAD
 1097 FORMAT(14HTOXIC DEATH   ,2A10,1H$)
      ENCODE(50,1098,TITL2) HEAD
 1098 FORMAT(15HTOXIC INJURY   ,2A10,1H$)
   40 CALL TITLE(TITL,-100,14HX DISTANCE(KM),
     114,14HY DISTANCE(KM),14,12.0,8.0)
      CALL GRAF(0.,XINC,XLIM,YMIN,YINC,YLIM)
      CALL MARKER(1)
       CALL BLNK1(3.8,8.4,7.0,8.3,1)
      CALL CURVE(XAA,YAA,NJ,-1)
      IF(NJ .EQ. 0)GO TO 70
      J=1
   56 CONTINUE
      XX=XAA(J)-0.1
      YY=YAA(J)
      XTES=XAA(J)-XAA(J-1)
      YTES=YAA(J)-YAA(J-1)
      IF (XTES .EQ. 0. .AND. YTES .EQ. 0.) H(J)=H(J-1)
      ENCODE(20,58,U)H(J)
   58 FORMAT(1H ,I3,1H$)
      CALL RLMESS(U,100,XX,YY)
      IF(J .EQ. NJ)GO TO 70
      J=J+1
      IF(J .GT. 400)GO TO 70
      GO TO 56
   70 CONTINUE
      IF(NP(4) .EQ. 4)GO TO 48
      NJMP=1
      IF (UWIND. LE. 5.0) NJMP=2
      CO 50 I=2,NI2,NJMP
       JJ=0
      DO 80 J=1,101
      IF(AX(I,J).LE.0.) GOTO 80
      IF(ABS(AY(I,J)).GT.YMAX.OR.AX(I,J).GT.XMAX) GOTO 80
      JJ=JJ+1
      DX(JJ)=AX(I,J)
      DY(JJ)=AY(I,J)
      DY1(JJ)=-DY(JJ)
   80 CONTINUE
      CALL CURVE(DX,DY,JJ,0)
      CALL CURVE(DX,DY1,JJ,0)
      KI=5*(I-1)
      ENCODE(40,26,LSTRNG)KI
   26 FORMAT(I3,6H MINS$)
      CALL LINES(LSTRNG,IPK,1)
      XPOS=AX(I,51)/XSCAL
      YPOS=4.0-AY(I,51)/YSCAL+YPOSII
      YPOSII=YPOSII+0.3
      CALL STORY(IPK,1,XPOS,YPOS)
      IF(I .EQ. NI2)GO TO 54
      IF(I .GT. 25)GO TO 54
       IF(I.EQ.5.OR.I.EQ.10.OR.I.EQ.15.OR.I.EQ.20) YPOSII=0.
```

FIGURE D-4 (continued)

```
      50 CONTINUE
      48 CALL CURVE(BX,BY,NI4,0)
         CALL CURVE(BX,BY1,NI4,0)
      54 ENCODE(50,60,LST)UWIND
          CALL RESET (5HBLNKS)
      60 FORMAT(9HWIND VEL ,F5.2,5H M/S$)
         CALL LINES(LST,IPK1,1)
         CALL STORY(IPK1,1,4.0,8.0)
         CONCEN=CONCEN*1000.
         ENCODE(60,62,LTV)CONCEN
      62 FORMAT(21HLTV FOR IRRITATION = ,E9.3,6H G/CC$)
         CALL LINES(LTV,IPK2,1)
         CALL STORY(IPK2,1,4.0,7.6)
         ENCODE(60,64,LTV)TMG
      64 FORMAT(13HVAPOR MASS = ,E9.3,4H KG$)
         CALL LINES(LTV,IPK2,1)
         CALL STORY(IPK2,1,4.0,7.2)
         CALL ENDPL(-1)
      71 CONTINUE
C        THE FOLLOWING IS FOR PLOTTING TOXIC CASUALTLY
C        NP=10 PLUME TOXIC DEATH,  NP=11 PLUME TOXIC INJURY
C        N=12 PUFF TOXIC DEATH, N=13 PUFF TOXIC INJURY
         IF (IDRAW .EQ. 0) GOTO 3000
     131 DO 1100 I=1,2
         IF(I .EQ. 1)CALL TITLE(TITL1,-100,14HX DISTANCE(KM),
        114,14HY DISTANCE(KM),14,12.0,8.0)
         IF(I .EQ. 2)CALL TITLE(TITL2,-100,14HX DISTANCE(KM),
        114,14HY DISTANCE(KM),14,12.0,8.0)
         XGRT=XGR(I)
         YGRT=YGR(I)
         IF(XGRT .LT. 10.0)GO TO 322
         IF(XGRT .LT. 100.0)GO TO 323
         IF(XGRT .LT. 1000.0)GO TO 324
     322 XGRT =XGRT+0.5
         XTOP=XGRT-AMOD(XGRT,0.5)
         XDEL=XTOP/4.0
         GO TO 222
     323 XGRT=XGRT+5.0
         XTOP=AINT(XGRT)
         XDEL=XTOP/4.0
         GO TO 222
     324 XGRT=XGRT+50.0
         XTOP=XGRT-AMOD(XGRT,5.0)
         XDEL=XTOP/4.0
     222 IF(YGRT .LT. 0.1)GO TO 332
         IF(YGRT .LT. 1.0)GO TO 333
         IF(YGRT .LT. 10.0)GO TO 334
         IF(YGRT .LT. 100.0)GO TO 335
     332 YGRT=YGRT+.005
         YTOP=YGRT-AMOD(YGRT,.005)
         YDEL=YTOP/2.0
         GO TO 224
     333 YGRT=YGRT+0.05
         YTOP=YGRT-AMOD(YGRT,0.05)
         YDEL=YTOP/2.0
         GO TO 224
     334 YGRT=YGRT+0.5
         YTOP=YGRT-AMOD(YGRT,0.5)
         YDEL=YTOP/2.0
         GO TO 224
```

FIGURE D-4 (continued)

```
  335 YGRT=YGRT+5.0
      YTOP=AINT(YGRT)
      YDEL=YTOP/2.0
  224 XSCAL=XTOP/12.0
      YSCAL=YTOP/4.0
      YBOT=-YTOP
      WRITE(6,1079)XTOP,YTOP,YBOT,XDEL,YDEL
      L=1
      DO 402 J=1,NI1
      XAA(J)=0.0
      YAA(J)=0.0
  402 CONTINUE
      DO 404 J=1,NI1
      IF(XA(J) .LT. 0.0 .OR. XA(J) .GT. XGRT)GO TO 404
      IF(ABS(YA(J)) .GT. YGRT)GO TO 404
      M(L)=J
      XAA(L)=XA(J)
      YAA(L)=YA(J)
      NJ=L
      L=L+1
  404 CONTINUE
      CALL GRAF(0.0,XDEL,XTOP,YBOT,YDEL,YTOP)
      CALL MARKER(1)
      CALL BLNK2(3.8,7.8,7.4,8.3,1)
      CALL CURVE(XAA,YAA,NJ,-1)
      IF(NJ .EQ. 0)GO TO 171
      L=1
  140 CONTINUE
      XX=XAA(L)+.1
      YY=YAA(L)
      XTES=XAA(L)-XAA(L-1)
      YTES=YAA(L)-YAA(L-1)
      IF (XTES.EQ.0. .AND.YTES.EQ.0.) M(L)=M(L-1)
      ENCODE(20,142,U)M(L)
  142 FORMAT(1H ,I3,1H$)
      CALL RLMESS(U,100,XX,YY)
      IF(L .EQ. NJ)GO TO 171
      L=L+1
      IF(L .GT. 400)GO TO 171
      GO TO 140
  171 CONTINUE
      KJ=1
      DO 1105 J=1,5
      IF (J. EQ. 2 .OR. J .EQ. 4) GOTO 1105
      YCM=1.0E-5
      XCM=0.0
      KN=NK(I,J)
      DO 1110 K=1,KN
      XC(K)=CX(I,J,K)
      YC(K)=CY(I,J,K)
      YC1(K)=-YC(K)
      IF(YC(K) .GT. YCM)GO TU 207
      GO TC 1110
  207 YCM=YC(K)
      XCM=XC(K)
      KJ=K
 1110 CONTINUE
      CALL CURVE(XC,YC,KN,0)
      CALL CURVE(XC,YC1,KN,0)
      ENCODE(50,209,LST)PECNT(J)
```

FIGURE D-4 (continued)

```
  209 FORMAT(F5.1,3H % ,1H$)
      CALL SCMPLX
      CALL LINES(LST,IPK1,1)
      XPOS=XCM/XSCAL
      YPOS=4.0+YCM/YSCAL
      CALL STORY(IPK1,1,XPOS,YPOS)
 1105 CONTINUE
      CALL RESET(5HBLANKS)
      CALL SIMPLX
      ENCODE(60,68,LTV)UWIND
   68 FORMAT(11HWIND VEL = ,F5.2,5H M/SS)
      CALL LINES(LTV,IPK2,1)
      CALL STORY(IPK2,1,4.0,8.0)
      ENCODE(60,67,LTV)TMG
   67 FORMAT(13HVAPOR MASS = ,E9.3,4H KGS)
      CALL LINES(LTV,IPK2,1)
      CALL STORY(IPK2,1,4.0,7.6)
  144 IF(I .EQ. 1)CALL ENDPL(-2)
      IF(I .EQ. 2)CALL ENDPL(-3)
 1100 CONTINUE
 3000 CONTINUE
      WRITE (6,3002) IDRAW
 3002 FORMAT(/* IDRAW= *,I2)
      CALL DONEPL
      END
```

FIGURE D-4 (concluded)

```
79/06/12. 12.42.58.
PROGRAM   CALPLOT

/JOB
CALPLOT,T30,P2.
USER(
PROJECT,
COPYBF,,PLOTF.
ROUTE(PLOTF,DC=PR,UN=PLOTTDC)
/EOR
/READ,PLTINFO
/EOR
/NOSEQ
/NOPACK
/TRANS
/READ,PLOTF
/EOF
READY.
```

FIGURE D-5. CALPLOT

```
79/06/12. 12.43.51.
PROGRAM   PLTINFO

PLOTINFO
CHARGE,
CUSTOMER NAME, U.S. COAST GUARD
INITIATOR, B. ARTICOLA/ECI
PHONE,
PRIORITY, REG
PAPER TYPE, PLAIN
PAPER SIZE, 11
NUMBER OF PENS, 1
PEN 1, BLACK,INK
DELIVERY INSTRUCTION, HOLD
PLOTEND
READY.
```

FIGURE D-6. PLTINFO

U.S. GOVERNMENT PRINTING OFFICE: 1980 634-134/1165